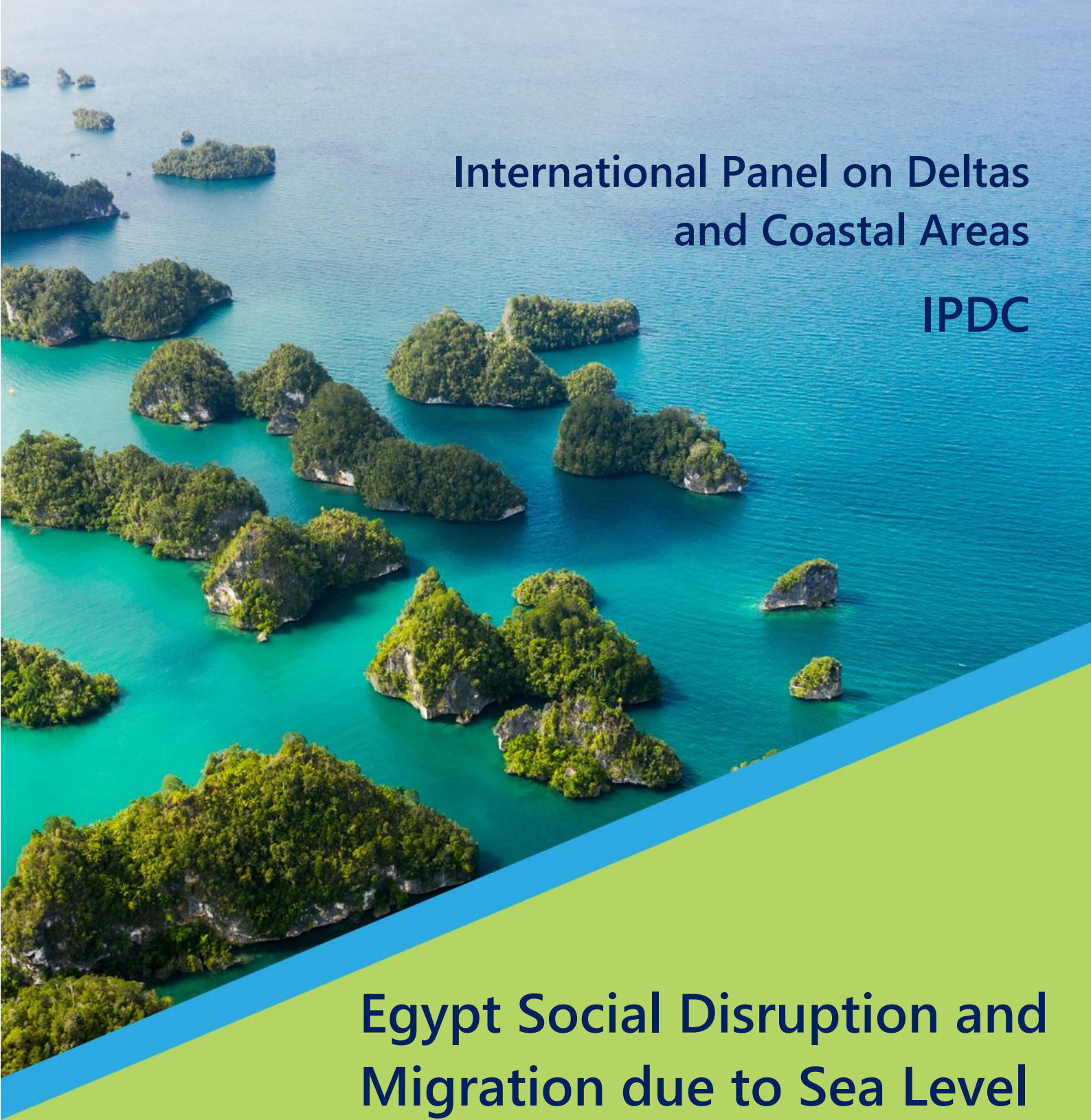

International Panel on Deltas and Coastal Areas

IPDC

Egypt Social Disruption and Migration due to Sea Level Rise

Results from Egypt SLR Hackathon

IPDC Secretariat

September 2025

Egypt Social Disruption and Migration due to Sea Level Rise

Results from Egypt SLR Hackathon

The Report was authored by Toka Mahmoud as a consultant for the International Panel for Deltas and Coastal Areas (IPDC) within the framework of the IPDC project: Egypt Sea Level Rise Hackathon in February 2024.

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Summary

Sea level rise (SLR) poses a substantial danger to Egypt's North Coast and Delta, affecting Egypt as a whole. The World Bank (2022) reports that globally, Egypt is the fifth most vulnerable country to the socio-economic impacts of SLR on cities. With SLR, coastal erosion, flooding, saltwater intrusion into freshwater, and land salinization will increasingly threaten this significant region's survival. This affects the livelihoods of numerous communities, including fishermen, farmers, and urban residents.

This report explores the impacts of SLR on Egypt's North Coast and Delta, focusing on key social disruption and migration (SDM)-related impacts. The report is grounded on the findings of the Egypt SLR Hackathon (February 2024), which carried out rapid assessments and expert judgments across several areas. Detailed findings from these assessments are in a separate report Egypt SLR Hackathon Report (IPDC, 2025).

The analysis presented herein integrates scientific and non-scientific literature, open-access data, the flood extend maps and SLR scenarios from the hackathon results, and contributions gathered during the event through a questionnaire and expert interviews to (1) identify key SDM-related impacts of SLR in Egypt and (2) outline mitigation pathways.

The analysis framework is a modification of that from (Mahmoud, Patrahau, & Vignali, 2023). The framework relates the slow-onset impacts of SLR to SDM through insecurities in basic needs (water, food, healthcare, income, education), which prompts individuals to resort to one or more coping mechanisms like migration, seeking alternatives, or protesting. The choice of these mechanisms depends on the broader context and individual characteristics such as age, gender, and education level. The estimates are validated in comparison to existing data; most notably in 2020, the total number of external emigrants from Egypt was 3.6 million (Statista, 2024b).

This report is a first step to explore connections in a largely unexplored and insufficiently researched area in Egypt. We aim to provide rough, quantifiable estimations of potential SDM-related responses to SLR in Egypt's North Coast and Delta, highlighting the seriousness of the issue and the need for further in-depth research.

SDM-related impacts of SLR in Egypt's North Coast and Delta remain an uncharted area. By 2100, these impacts could extend beyond directly affected areas, disrupting agriculture, infrastructure, and economic activities vital to Egypt's economy, with broader implications for the entire region.

Key findings

- Spatial extent of key SDM-related impacts of SLR: The analysis identifies the affected population (projected to 2100) and highlights key SLR focal regions for SDM in Egypt (Figure 1). Focal regions include Alexandria, Port Said, Damietta, Kafr El-Sheikh, Beheira, and Dakahlia. The spatial analyses are based on the flood extent maps due to SLR scenarios from the hackathon results, CAPMAS population density data, and a combination of scientific and non-scientific sources. Expert interviews conducted during the hackathon also contribute valuable insights into the biophysical pressures, community coping mechanisms, and vulnerability disparities currently impacting Egypt's North Coast and Delta. Spatial findings are detailed in Chapter 5.

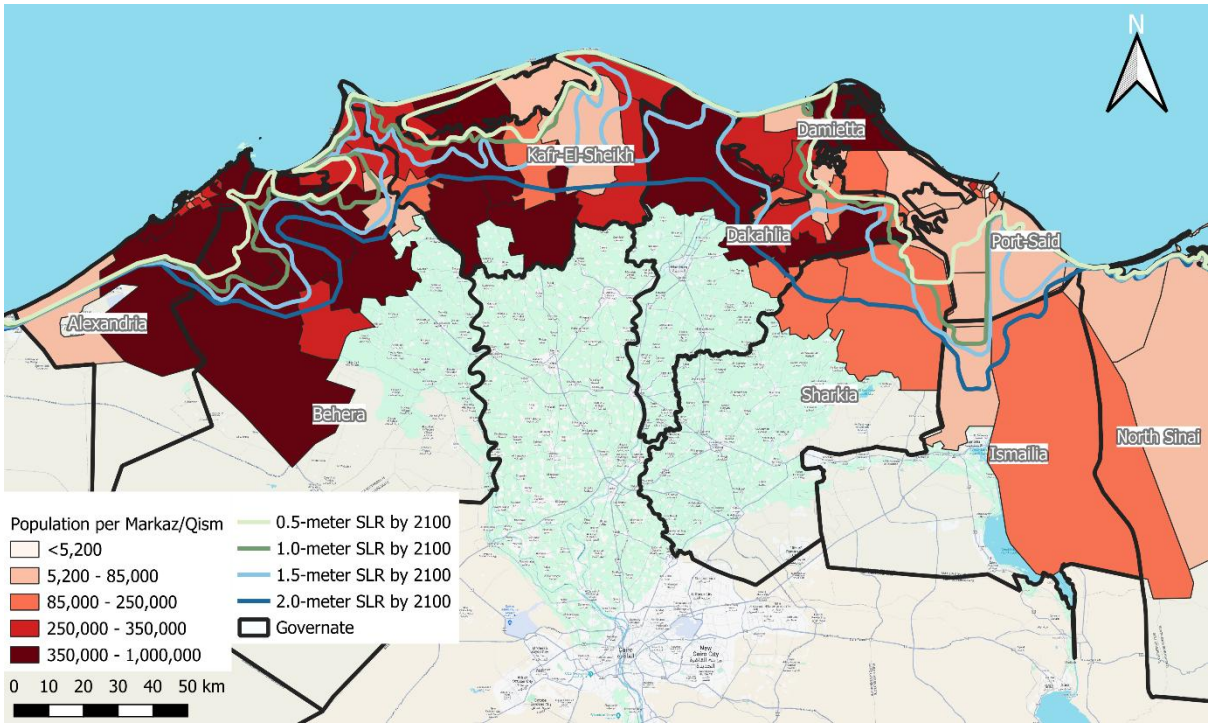


Figure 1 The spatial extent of the SLR social impacts: Map of Residents in Affected Governorates (projection 2100)

- Coping Mechanisms in Numbers: Table 1 presents estimates of the total affected population distributed per coping mechanism for each SLR scenario. Building on the previous GIS analysis, the numbers are estimated using data from a questionnaire conducted during the 2024 Egypt SLR Hackathon. The methodology of the estimation is detailed in Chapter 6.

  The results show that the highest number of responses were for 'Searching for Alternative Economic Opportunities' within the same location, indicating that individuals mainly adapt by pursuing new opportunities locally. Following this, 'Internal Migration' and 'External Migration' were the next most common responses, with internal migration occurring slightly more often than external migration.

Table 1 Estimated Affected Population by Coping Mechanism- 2100 projections (Numbers are grounded on questionnaire results and the scenarios of flooding extent provided by the hackathon teams' reports in combination with relevant spatial data published by CAPMAS)

SLR (2100)	Total Number by 2100 (Million)						
	Do Nothing	Search for Alternative Economic Opportunities	Use Household Adaptation Measures	Internal Migration	External Migration	Protests	Violence
0.5 m	0.41	15.50	1.60	9.31	6.52	3.80	0.68
1.0 m	0.71	18.58	2.27	11.56	8.25	4.16	0.76
1.5 m	1.35	25.39	4.13	16.60	12.68	4.71	0.94
2.0 m	2.36	30.74	5.52	21.22	15.87	4.87	0.99

- Breakdown of Coping Mechanisms: A breakdown of employed coping mechanisms, including the locations where they are expected, by whom and under what conditions is given below. This breakdown is also based on the data from the questionnaire, as detailed in Chapter 6**.**

    a. Violence: Predominantly in the urban centres: Alexandria and Port Said, driven by financial concerns and distrust in government. Mostly young to middle-aged men with lower education levels.

    b. Protests: Similar to violence, prevalent in Alexandria and Port Said, involving mainly young and middle-aged men farmers and fishermen, with lower education levels.

    c. External Migration: Notably in Damietta and Kafr El-Sheikh, driven by financial concerns, SLR knowledge, and low trust in government. Involves younger generations of fishermen and farmers, mostly with intermediate education. The external migration statistics presented here underscore significant concerns, as they reveal a trend approximately double that of the current external migration trend from Egypt.

    d. Internal Migration: Prominent in Beheira and Dakahlia, engaging a diverse group, influenced by financial reasons, with a significant role of social networks. This indicates that the estimated trend is projected to reach approximately 1.3 times the existing rate of internal migration.

    e. Using Household Adaptation Measures: Common in Damietta, Kafr El-Sheikh, Beheira, and Dakahlia, used by older populations mostly with lower education levels, driven by financial needs and SLR risk awareness.

    f. Searching for Alternative Economic Opportunities (in the same location): Significant in Alexandria and Port Said, where educated farmers and workers are increasingly seeking solutions due to financial pressures and SLR risks.

    g. Inaction ("Do Nothing"): Predominantly in Beheira and Dakahlia, mostly among middle-aged women with lower education, influenced by financial concerns and their knowledge of the risks of SLR.

- Mitigation Pathways*:* the following summary is an opinion-based analysis of the most effective mitigation pathways for three governorate groups across Egypt SLR focal regions for SDM: Alexandria & Port Said, Damietta & Kafr El-Sheikh, and Beheira & Dakahlia, categorized into Technical/National Measures and Community-Oriented Measures. This summary is grounded on answers from the questionnaire, as described in Chapter 7.

    - In the Technical/National Measures category, Alexandria & Port Said, and Damietta & Kafr El-Sheikh demonstrate a balanced focus on approaches like flood protection, wet infrastructure, and international investment. Beheira & Dakahlia, however, emphasize international investment, indicating a reliance on external funding. Measures such as improving institutional capacity and providing subsidies for resilient housing, while less emphasized, are considered across all regions.
    - For Community-Oriented Measures, social equity and stakeholder engagement are prioritized in Alexandria & Port Said and Beheira & Dakahlia. Notably, “Special Education” initiatives are highlighted in Beheira & Dakahlia to equip communities with skills for diversifying livelihoods beyond farming and fishing, promoting long-term resilience.
    - Additionally, experts stress the importance of supporting NGOs to enhance their capacity for implementing community adaptation and capacity-building interventions, complementing government efforts in resilience-building. Relocation of communities,

while considered, is a lower priority across all regions due to its complexity and perceived lesser necessity.

Uncertainties and Reflections

We acknowledge the inherent uncertainties of studying the phenomena of SDM and its association with SLR. The nexus between SLR and SDM is complex, interconnected and context-specific. SDM is shaped by people's decisions influenced by their unique characteristics, perceptions, and living conditions, while both phenomena exhibit slow-onset impacts. Moreover, Egypt's North Coast and Delta are highly vulnerable to socio-economic pressures, with incidents of flooding and livelihood losses already prompting migration and other coping strategies. The gradual and often imperceptible nature of SLR, combined with the complex and intertwined factors driving SDM, could alter regional dynamics over time, entirely changing the potential numbers presented here. **These uncertainties render the report highly speculative and the findings indicative rather than precise.** However, the findings are significant and underscore the relevance of the issue, highlighting the critical need for further research.

The findings confirm that the identified governorates are critical SLR focal regions in Egypt, already experiencing livelihood deterioration that SLR will intensify. The identified communities in these regions are likely to adopt the specified coping mechanisms in response to livelihood losses, however, the timing of such responses remains uncertain. The projected numbers require further research and validation, as they are based on preliminary hackathon results. Ongoing research will help address these uncertainties and deepen understanding as SLR impacts evolve.

Given the critical importance of Egypt's North Coast and Delta, this report underscores the urgent need for detailed studies to quantify future SLR impacts, track coping mechanisms, and understand the extent of social disruption. Effective management and governance could reduce climate change-related SDM impacts by up to 80%, as evidenced by research (Clement et al., 2021).

While this report provides rough estimates of potential SDM responses to SLR, its primary goal is to spark necessary conversations, emphasizing the critical need for further research. It offers an innovative perspective, paving the way for more detailed and comprehensive studies. These studies are vital for addressing the impacts of SLR in Egypt's North Coast and Delta, which are critical to the nation's overall survival. Strategic planning, effective governance, and ongoing research are essential to mitigate potential adverse effects on this region and beyond.

Abbreviations

CAPMAS	The Central Agency for Public Mobilization and Statistics
CGIAR	Consultative Group on International Agricultural Research
EEA	The Egyptian Ministry of Environment
FAO	The Food and Agriculture Organization of the United Nations (FAO)
GF	Governance and Finance
GIS	Geographic Information System
IPCC	The Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LECZs	Low-Elevation Coastal Zones
MWRI	The Egyptian Ministry of Water Resources and Irrigation
NWRC	National Water Research Centre
SDM	Social Disruption and Migration
SLR	Sea Level Rise

1 Introduction

1.1 Background

In recent years, policymakers have increasingly recognized water insecurity[1] as a major driver of social disruption[2] and migration (SDM), given their close interconnection. Rapid shifts in migration patterns can destabilize community structures, while social disruptions can impact migration, creating a self-reinforcing cycle. SDM, particularly linked to water insecurity, including cases of sea-level rise (SLR), has gained attention in global frameworks such as the Agenda for Humanity, the 2016 United Nations Summit for Refugees and Migrants, the Global Compact for Migration, and the Global Compact on Refugees. These platforms highlight the need to address the complex challenges of slow-onset water insecurity, marking a shift in how environmental change, social disruption, and human mobility are understood and addressed (Stoler et al., 2021).

Conversely, the scientific community has studied such social impacts of biophysical phenomena. For instance, some studies have linked water insecurity to changes and dysfunctions within communities' social structures and interactions such as increased levels of anxiety and depression, and in severe conditions, elevated risk of suicide (Amber Wutich & Brewis, 2014; A Wutich, Brewis, & Tsai, 2020). The challenges of living with water insecurity not only cause anxiety but also result in social stigma, hinder fulfilling gender roles, disrupt relationships, and intensify inequalities and injustices (Kangmennaang, Bisung, & Elliott, 2020). Studies have even indicated a correlation between water insecurity and an increased likelihood of women reporting domestic violence (Pommells, Schuster-Wallace, Watt, & Mulawa, 2018; Stevenson et al., 2012).

Other studies have attempted to quantify these social impacts. The World Bank projects that slow-onset climate phenomena, including SLR, could result in more than 216 million internal migrants by 2050 (Clement et al., 2021). The United Nations states that water insecurity is already causing the internal migration of 20 million people per year (United Nations, 2022). A recent study suggests that SLR in the Mediterranean region particularly could lead to the internal migration of up to 20 million people by 2100 (Reimann et al., 2023).

It is well-established in the literature that climate-related SDM are rising and the escalating climate hazards in the forthcoming years will further expedite this pattern. Climate-induced SDM are expected to increase steadily until 2050. Following, they are projected to accelerate unless effective development measures are implemented (Rigaud et al., 2018). While there isn't consensus on the precise quantification of climate-related SDM, the United Nations reported that approximately forty-four percent of the global population resides within 150 kilometres of coastlines, putting them at risk of water insecurity-related challenges (UN, 2024).

North Africa is expected to experience the highest proportion of climate-related SDM, with Egypt's North Coast and Delta region among the most vulnerable areas. This is primarily attributed to severe water scarcity and the effects of SLR on densely populated coastal areas and the Nile Delta (Clement et al., 2021). Based on models that only considered population forecasts and hydraulic forecasts such as inundation levels, coastal erosion and storm surges, a study in the early 2000s projected that 13 million people residing in Egypt's North Coast and Delta could be displaced between 2000 and 2050 (Ericson,

[1] Defined as a water situation with inadequate quantity and quality for human well-being and socio-economic activities (World Bank, 2017)

[2] Social disruption is a broad term encompassing significant changes, dysfunctions, or breakdowns within a community's social structures and interactions (Beck, 2016; Schrijvers et al., 2021).

Vörösmarty, Dingman, Ward, & Meybeck, 2006). Nonetheless, studies on the multifaceted impacts of SLR on SDM in Egypt remain scarce.

This report is one of the first serious efforts to quantify such phenomena in Egypt's North Coast and Delta. It builds on findings from the Egypt SLR Hackathon (February 2024) using scientific references (peer-reviewed articles, official reports, data repositories), non-scientific references (reportages, press archives), as well as expert interviews and a questionnaire conducted with hackathon participants.

The hackathon rapidly assessed the impacts of SLR on three key sectors: Agriculture, Infrastructure, and Health and Environment. A description of the event is provided in Section 1.2. These assessments generated scenarios of flooding extent and potentially affected population due to SLR of 0.5, 1.0, 1.5, and 2.0 meters by 2100 in Egypt's North Coast and Delta. The projections, while preliminary and aligned with the rapid nature of the event, are based on the Intergovernmental Panel on Climate Change (IPCC) warming scenarios. Detailed findings from these assessments will be presented in the companion Egypt SLR Hackathon Report (IPDC, 2025).

The flood extent maps and scenarios from the hackathon provide a foundation for quantifying SLR-related SDM in this report. Hence, this report should not be viewed as a definitive research study or final assessment. The rapid nature of the hackathon introduces uncertainty, and predicting precise numbers of people affected by SLR-related SDM is inherently challenging due to the complex and progressive interplay between SLR and SDM.

Despite these limitations, this report offers an innovative perspective and a bold attempt to explore connections in a largely uncharted and insufficiently studied area. It highlights the urgent need to address SLR-related SDM in Egypt. It calls for further research and proactive dialogue while offering insights into how social groups may respond to livelihood disruptions caused by SLR in Egypt. Further research will help address these limitations as the impacts of SLR become more evident over time. This report is a crucial starting point for mitigating and adapting to SLR's social consequences, aiming to spark necessary conversations and research rather than provide conclusive findings.

1.2 Egypt Sea Level Rise (SLR) Hackathon Event

Implementing proactive measures and innovative solutions to address and alleviate the impacts of SLR in Egypt's North Coast and Delta is indispensable. Therefore, the Egypt SLR Hackathon event was proposed as a dynamic and collaborative platform to bring together a consortium of national and international experts for brainstorming solution pathways.

Deltares facilitated an extensive consultation session during Cairo Water Week 2023 to prepare for the hackathon event. Throughout this session, participants engaged in discussions that spanned a wide spectrum of topics perceived to be relevant for the analysis during the Hackathon. Drawing from the insights gained at the pre-hackathon event, a catalogue of challenges, related research questions, and potential solution pathways were assembled. Primary challenges coalesced around three pivotal aspects: (I) Agriculture, (II) Infrastructure, and (III) Health and Environment. Additionally, the scope encompassed two cross-domain aspects: Social Disruption and Migration (SDM), and Governance and Finance (GF). Research questions were grouped to match the pivotal and cross-domain aspects. Finally, potential solution pathways were identified and categorized into three themes (I) Protect, (II) Accommodate and (III) Relocate. The hackathon's detailed description and results will be presented in the companion Egypt SLR Hackathon Report.

The Hackathon was intensive and collaborative. Three competing teams were assembled for each pivotal aspect to execute related tasks. Furthermore, cross-domain experts on SDM, and GF were present to guide the teams while implementing their respective tasks. A diverse array of participants, including young researchers/professionals and experts from Egypt and The Netherlands worked together over a

few days to tackle the previously identified research questions. The teams addressed the research questions using various resources such as maps and datasets, often enriching their findings with mathematical models or Geographic Information System (GIS) operations. For each pivotal aspect, two main tasks were undertaken, beginning with a rapid assessment charting the ramifications of SLR (Task A), followed by Task B, which delved into potential solution pathways. The teams compiled, reported, and presented their outcomes during the event's last day. Lastly, a panel of experts rated the outcomes and chose a winning team.

1.3 Social Disruption and Migration (SDM) Cross-Domain Aspect

Exploring key critical connections between SLR and SDM aims to provide an understanding of the far-reaching impacts of SLR. Such analysis will inform policymaking and community planning to enhance resilience against future SLR. This is essential for addressing the challenges posed by a future where water vulnerability is a growing concern for all.

The SLR Hackathon event facilitated a dynamic and collaborative platform that brought together national and international experts to brainstorm and propose innovative solutions for mitigating the impacts of SLR in Egypt. However, most participants were not experts on the nexuses between SLR and SDM. Yet, they have extensive experience working on water-related issues in Egypt and many have performed field research among different Egyptian communities.

Therefore, the SDM Cross-Domain Aspect encompassed two primary objectives during the event. Firstly, to assume a supporting role to introduce participants from different disciplines to the interconnectedness between SLR and SDM. The goal was to ensure that teams considered the social implications of the proposed measures. Secondly, collect information from the Hackathon participants as input for producing a policy-relevant report.

1.4 Report Structure

This report investigates SDM under scenarios of 0.5, 1.0, 1.5, and 2.0 meters of SLR by the year 2100, which has been analysed in a hackathon context. These projections, though rough estimations aligned with the rapid nature of a hackathon event, are based on IPCC scenarios in addition to a uniform 0.5-meter land subsidence across the study area. The SDM analysis draws insights from scientific literature and non-scientific publications, the impact assessment made during the hackathon, and relevant demographic and spatial datasets, in addition to a questionnaire and expert interviews conducted during the hackathon event.

Chapter 1 provides the report's background, an overview of the Egypt SLR Hackathon, including the aim and objective of the SDM Cross-Domain Aspect, and the report's structure. Chapter 2 explores literature that provides empirical evidence on the potential links between SLR and SDM through cases in Bangladesh, Indonesia, and Vietnam. Subsequently, it reviews scientific publications on the evolving discourse surrounding the key links between SDM and slow-onset water insecurity, focusing on SLR and highlighting the complexity of this relationship. Chapter 3 uses scientific literature to develop the report's analysis framework and methodology. Using scientific and non-scientific references and demographic data, Chapter 4 introduces Egypt's North Coast and Delta region by emphasizing its socioeconomic significance and demographic structure, and identifying key SLR-related biophysical pressures. Subsequently, the chapter utilizes a combination of press archives and insights from the

performed expert interviews to identify current communities' vulnerabilities, different coping mechanisms[3] and disparities.

Based on the flood extent maps and scenarios provided by the hackathon in combination with relevant spatial data, Chapter 5 quantifies key asset losses and maps the most vulnerable areas and affected populations in Egypt's North Coast and Delta under the varying SLR scenarios.

Chapter 6 uses the analysis framework to predict future SLR-related SDM trends, integrating literature, demographic and spatial data, the questionnaire, and interviews. The chapter identifies the most probable community coping mechanisms and details influencing factors in addition to the characteristics of the populations involved.

The report concludes in Chapter 7 by exploring mitigation and adaptation strategies tailored to Egypt, offering pathways to reduce vulnerabilities and enhance resilience against SLR impacts. This structure ensures a concise and comprehensive understanding of SLR's implications for SDM and potential solutions.

1.5 Disclaimer

This report is a first step to exploring connections in a largely unexplored and insufficiently researched area. Herein we aim to provide quantifiable estimations of potential SDM-related responses to SLR in Egypt's North Coast and Delta, highlighting the seriousness of the issue and the need for further in-depth research. The estimates made in this report are rough and require comprehensive research to build more confidence in their reliability. SDM-related impacts of SLR in Egypt's North Coast and Delta remain an uncharted area. While the quantification of SDM due to SLR is challenging, the findings are significant, underscoring the urgency of the issue and highlighting the critical need for further research.

[3] A strategy or method employed by individuals or communities to handle and adjust to difficult or stressful circumstances.

2 Understanding the Nexus: SDM in the Context of SLR

2.1 Empirical evidence linking SLR and SDM

In Bangladesh, the frequent floodings of river chars and riverbank erosion may be analogous to SLR and shoreline erosion. This and its associated natural hazards have caused SDM in the riverine island (char) areas. A study performed on 280 affected households in affected areas showed that almost 100% percent of the migrant households faced significant livelihood losses as well as community and domestic disturbances, including food insecurity, unemployment, income reduction, and housing and sanitation issues at their origin sites. Moreover, almost all households indicated that they still face similar challenges in their destination cities (Hossain et al., 2022). The situation in Bangladesh is expected to worsen in the foreseeable future. A substantial number of individuals will be compelled to migrate as a result of these developments. Bangladesh, highly vulnerable to the impacts of climate change, may witness the mobility of as many as 30 million people by 2100 should sea levels rise to the estimated 80 cm or beyond (Barua, Rahman, & Molla, 2017).

In Indonesia, SLR is threatening the livelihoods of communities in low-elevation coastal zones (LECZs) such as Jakarta, Semarang, Jepara and Demak. In particular, SLR and salinization, coupled with land subsidence and coastal erosion, are disrupting daily lives and increasing the intensity and frequency of infrastructure flooding (Ayazi & Elsheikh, 2019). This is substantially impacting livelihoods. For instance, interviews with rice farmers have reported a decline in yields due to soil salinization and infrastructure flooding. This situation has forced many of them to adopt various coping mechanisms. Due to the lower maintenance costs, many farmers have converted their rice paddies to fishponds. However, this solution only addresses short-term needs, as fishermen report a significant decline in fish stocks caused by storms and coastal erosion that have damaged fishpond infrastructure. Additionally, some families have experienced land loss and irreversible damage, compelling many to relocate (Leal & Huaman, 2019). In Indonesia, the population at risk of flooding by 2100 could reach 42 million in the absence of adaptation measures (The World Bank Group and Asian Development Bank, 2021).

In addition, SLR has been linked to far-reaching impacts on Indonesian LECZs. A study has reported that SLR affected water storage facilities. As a result, household water quality is impacting health and nutrition. The ramifications of SLR have also intensified inequalities and injustices and affected vulnerable groups. Interviews with locals revealed that SLR has significantly affected children's education. Parents residing in Indonesian LECZs indicated that submerged roads and infrastructure have prevented children from attending schools. Some parents reported that lessons were conducted in unsafe environments, leading many to decide against sending their children to school. In addition, SLR has hindered gender roles in Indonesian LECZs. Although both men and women experience similar troubles, when resorting to different coping mechanisms these troubles are usually disproportionately greater for women due to their limited transferable skills and ties to household responsibilities (Leal & Huaman, 2019).

In Vietnam, economic and livelihood stressors have been triggers of SLR-related SDM. Research in Long An and Dong Thap provinces showed that SLR's stress on livelihoods is substantial, with poor income acting as the top trigger for SDM (Chun & Sang, 2012). In Quang Tri Province key triggers for migration were also economic. SLR-related issues including extreme weather contributed to crop failures, deteriorating livelihood conditions, and impacting migration decisions. Many fishermen in Ca Mau province have been facing fish stock decline due to similar SLR-related issues. They resolved to different coping mechanisms such as searching for alternative opportunities and migration (Ha Noi, 2014). Forecasts for Vietnam are pessimistic. Ho Chi Minh City could be severely affected by 2050, potentially prompting millions to relocate (Oppenheimer, 2019).

As for potential SDM-related far-reaching impacts of SLR, a study conducted in southern Vietnam highlighted the vulnerability of female migrant factory workers to gender-based violence, both from their partners and members of the community. These women, living away from the protective environment of their families and lacking social support networks in migrant housing areas, face heightened risks. The study also highlights how the migration of a family member has repercussions for those left behind, particularly elderly and middle-aged women, who may be tasked with caring for the children of migrants while managing agricultural responsibilities. Furthermore, the study highlights that in the Vietnamese context, SLR-related migration has significantly affected children, leading to family fragmentation, educational disruptions, and social network disconnection. Boys often find themselves employed in physically demanding sectors such as coal picking, fishing, or involvement in illicit activities like drug sales and trafficking. Meanwhile, girls frequently assume domestic responsibilities and, tragically, some may be coerced into the sex industry. Many young migrants, often unregistered, endure long working hours, receive minimal pay, and suffer from physical and mental stress and abuse (Ha Noi, 2014).

2.2 Key links between SLR and SDM

Different theories define SDM in various ways. Scholars initially described migration by highlighting macro-level 'push' and 'pull' factors at origin and destination sites. For example, employment opportunities and access to education and healthcare could attract individuals to certain areas (pull factors). In contrast, underdevelopment and lack of opportunities could push them away from their places of origin (push factors). However, this push-pull theory overlooks historical and political influences, as well as individuals' demographic characteristics, social networks, and agency. It also fails to explain instances where migration doesn't occur despite the presence of structural push/pull factors (Jónsson, 2010).

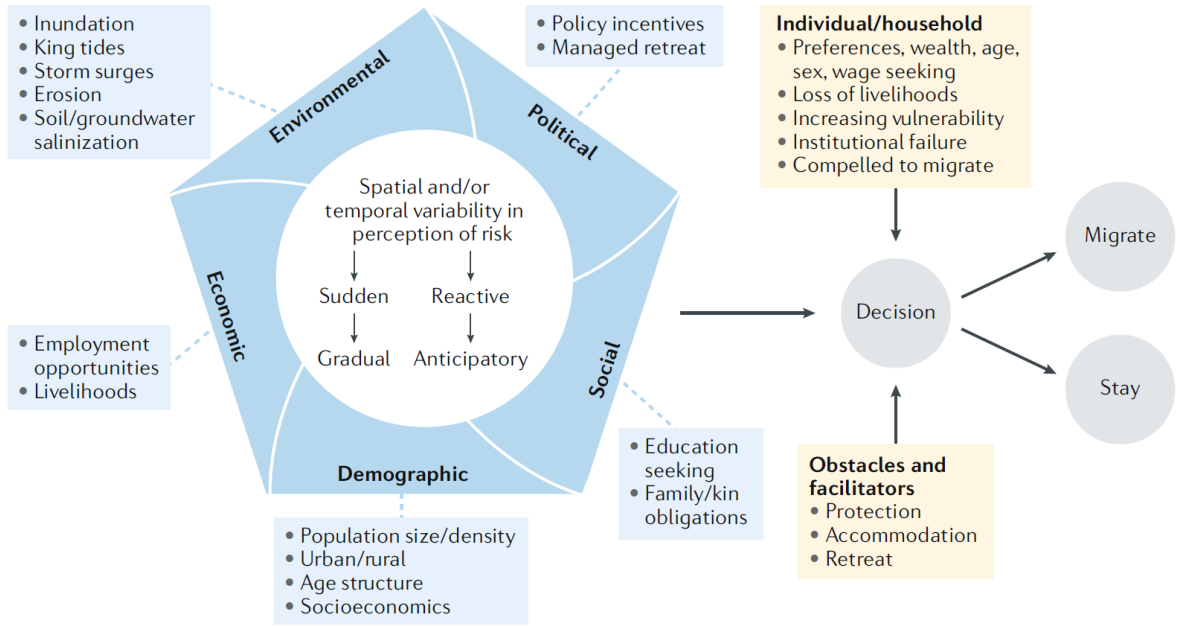


Figure 2 A schematic of the numerous factors influencing SLR-related migration; Source: (Hauer et al., 2020)

Recently, scholars have proposed that migration is driven by people's aspirations and ability to move. This means that SLR can prompt migration only if individuals desire to relocate, have the required resources and believe relocating will lead to better living conditions (De Haas, 2021; Schewel, Dickerson, Madson, & Nagle Alverio, 2024). This theory explains why people may migrate or stay despite economic opportunities and improved services. It makes clear that migration in the context of SLR is not only influenced by biophysical phenomena that deteriorate structural factors, but also by personal factors such as age, gender, education, and wealth. In addition, intervening obstacles and facilitators such as the cost of moving and social networks as well as protection, accommodation or retreat efforts exert great influence- Figure 2 (Hauer et al., 2020).

Individuals' needs such as water, food, income, health…etc act as pathways[4] that can potentially induce migration (Mahmoud et al., 2023; Zaveri et al., 2021). Yet, SLR-related migration is a decision made by individuals. Therefore, individuals and their living conditions possess a strong agency in shaping these migration patterns. This agency is determined by the unique characteristics, perceptions, and surrounding conditions of each individual (Flahaux & De Haas, 2016; Schewel et al., 2024).

On the other hand, social disruption is a broad term that encompasses any significant changes, dysfunctions, or breakdowns within a community's social structures and interactions (Beck, 2016; Schrijvers et al., 2021). SLR-related social disruption may result from community disturbances such as increased unemployment, competition over land and water, social inequity, increased poverty and attributed civil unrest- like protests and riots (United Nations, 2022). Additionally, social disruption may be a result of domestic issues such as family breakdown or domestic violence (Pommells et al., 2018; Stevenson et al., 2012). There is a substantial body of research exploring the impacts of environmental change on specific social disruption-related issues on the community or domestic levels. The vast majority of research in recent years acknowledges that environmental change, including SLR, acts through indirect pathways that affect people's needs such as water, food, income and health. This prompts individuals to resort to coping mechanisms such as searching for alternatives, migrating, or protesting (Mahmoud et al., 2023). The impacts of environmental change on social disruption greatly depend on the broader socio-political and economic contexts and individuals' characteristics and perceptions (Burrows & Kinney, 2016; Busby, 2018; Tallman et al., 2023).

2.3 Key complexities in the links between SLR and SDM

2.3.1 *The slow-onset nature of SLR*

SLR is a slow-onset phenomenon that progressively infiltrates coastal regions over time. Unlike sudden natural phenomena such as earthquakes or hurricanes, SLR happens incrementally, leading to gradual encroachment. This encroachment progressively raises soil salinity and causes saltwater intrusion- Figure 3. In addition, SLR is connected to incidents of extreme storms and floods (Gibson et al., 2021).

The biophysical impacts of SLR can be classified into two types: direct and slow-onset impacts. Direct impacts refer to habitable and arable land's seasonal or perennial submergence, leading to asset losses. Slow-onset impacts, on the other hand, are initially less visible and include issues such as increasing soil salinity and saltwater intrusion.

While it may be easier to project the socio-economic effects of direct impacts, the socio-economic consequences from slow-onset impacts add complexity. This indicates that slow-onset impacts, which

[4] In social science, it refers to a progression of social, economic, or cultural changes that collectively contribute to a significant transformation within society (Sen & Hickey, 2024).

vary based on salinity levels, saltwater intrusion extent, and regional vulnerability, can lead to significant disruptions well beyond threats of direct asset losses. Not to mention that SLR doesn't simply cause land losses; much of the flooding arises from the heightened impact of storm events, amplified by the higher mean sea level. The consequences are not confined to newly formed coastlines—this complex phenomenon affects inland areas, disrupting communities, economies, and ecosystems far from the immediate shore (World Bank, 2022).

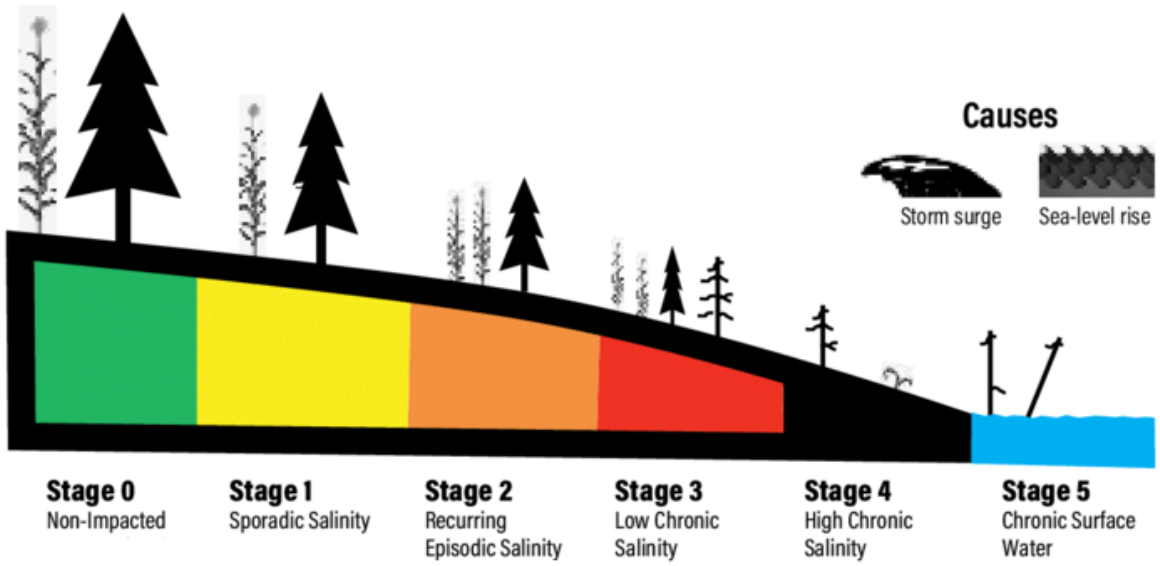


Figure 3 SLR Gradual Encroachment; Source: (Gibson et al., 2021)

2.3.2 *The complex, interconnected, and contextual factors of SLR-related SDM*

Migration, as a consequence of the slow-onset impacts of SLR, is driven by more diverse factors and is more extensive than displacement resulting from a short-term extreme event. Migration requires an active decision. Notably, migration requires the necessary resources. Severe poverty may act as a barrier to migration, effectively trapping the most vulnerable and leading them to resort to other coping mechanisms such as searching for alternatives or protesting (Black, Arnell, & Dercon, 2011; De Haas, 2021; Lubkemann, 2008). Similarly, SLR-related social disruption depends on individuals' personalities, perceptions, education, culture,. etc. (Stoler et al., 2021).

Though compelling and persuasive, the simple narrative directly linking SLR to SDM is overly simplistic. Even if severe and prolonged, SLR doesn't inevitably lead to SDM. Research on various contextual factors acknowledges the intricate causation involved and the complexity of individual responses to SLR. The reasons behind SDM in specific instances are inherently complicated and depend on the context (Cai, Feng, Oppenheimer, & Pytlikova, 2016; Jónsson, 2010; Mahmoud et al., 2023). Nonetheless, the inability to isolate specific aspects of SLR as direct and singular causes of SDM doesn't negate its status as a genuine contributing factor. Rather, it underscores its role within a multifaceted narrative encompassing environmental, socio-economic, and political pressures (Black et al., 2011; Tiboris, 2020).

Moreover, SLR can exhibit a dual impact on migration dynamics and social stability. SLR can induce migration, causing social disruption. Correspondingly, SLR-triggered social disruption can become a catalyst for increased migration. This intricate interplay creates a cycle that exacerbates vulnerabilities and inequalities, underscoring the interconnected nature of SLR, migration, and social disruption (Clement et al., 2021; IDMC, 2021).

Furthermore, SDM resulting from SLR is influenced by broader socio-political and economic contexts. A migrant does not label himself as a water migrant or a labour migrant before making his decision, nor does a person committing domestic violence, for instance, attribute his/her actions to SLR. While SLR may contribute to increased SDM, these phenomena are driven by diverse factors and are more complex than cause-and-effect phenomena like displacement caused by short-term extreme events (Mahmoud et al., 2023; Tiboris, 2020; Zaveri et al., 2021).

The gradual and often imperceptible nature of SLR, combined with the complex and intertwined factors driving SDM, means that SDM in response to SLR often goes unnoticed until it reaches a critical point. SDM in response to SLR builds up slowly over time, and the various contributing factors to SDM, such as economic stress, environmental degradation, and social vulnerabilities, become apparent only when they culminate in significant events. This complexity makes it difficult to identify SLR as the sole driver of SDM in specific incidents. It is more accurate to acknowledge that SLR has been a significant contributing factor, rather than the sole factor, influencing SDM (Rigaud et al., 2018).

3 Decoding SLR-related SDM: Analysis Framework & Methodology

This report integrates scientific and non-scientific literature, open-access data and contributions gathered during the hackathon through a questionnaire and expert interviews. Hence, a key priority of the event was to collect as much input and perspective as possible from participants to inform the report. The report has two main objectives: to identify the key social impacts of SLR in Egypt and to outline solution pathways.

The report explores potential SDM due to a 0.5-, 1.0-, 1.5- and 2.0-meter SLR by 2100. These scenarios are based on IPCC warming levels (Figure 4) in addition to a 0.5 m land subsidence, the latter distributed evenly over the study area. The selected land subsidence value provides a conservative estimate that balances the extremes of the observed range and aligns with the mid-range of previous studies, particularly when considering that the Nile Delta experiences subsidence rates ranging from 0.4 to 3.4 mm per year (IPCC, 2021).

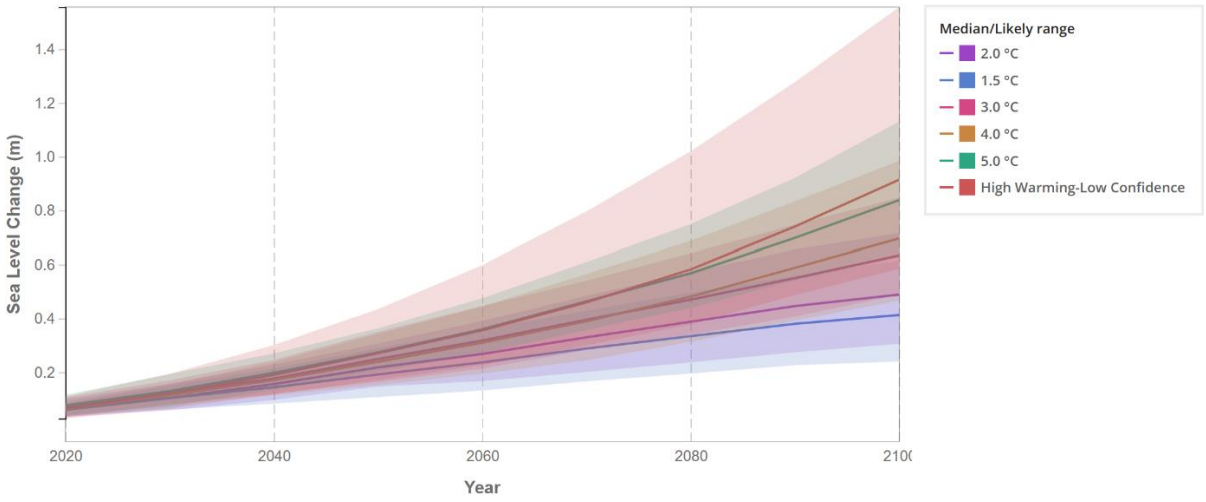


Figure 4 Projected Sea-Level Rise Under Different Warming Levels; (source: NASA Sea Level Change Portal, 2024)

The flood extent maps and scenarios from the hackathon provide a foundation for quantifying SLR-related SDM in this report. Hence, this report should not be viewed as a definitive research study or final assessment. The rapid nature of the hackathon and the complex, interconnected, and contextual factors surrounding SLR-related SDM introduce uncertainty. The potential impacts of SLR on SDM in Egypt have been significantly under-examined, while literature indicates that quantifying such phenomena is inherently difficult. However, the results presented in this report offer an innovative perspective by investigating connections in a field that remains largely unexplored and insufficiently studied (Hauer et al., 2020). This report marks one of the first efforts to begin bridging this gap. The report's primary value stems from the insights obtained during the analysis, such as understanding coping mechanisms, the individuals implementing them and determining where and why they are implemented.

To identify key SDM-related impacts of SLR in Egypt, the report combines the hackathon results and CAPMAS data on population densities to quantify the potentially affected population. Using the questionnaire results, it explores the most probable coping mechanisms used by different demographic groups. The report studies SLR-related mobility, including the nature of the mobility- cross-border or internal migration- as well as other coping mechanisms such as inaction, the use of household adaptation measures, protests, or violence. The report discusses the demographic characteristics of

individuals employing specific coping mechanisms and factors affecting these decisions. The report finally explores solution pathways.

3.1 Analysis Framework: Key Pathways from SLR to SDM

Figure 5 shows the analysis framework guiding the study. The framework was adopted and modified from (Mahmoud et al., 2023), a report published by the Water, Peace and Security partnership, discussing key indirect pathways from slow-onset water insecurity to migration. This specific framework was used because it categorizes SLR-related SDM into a clear flow diagram, making it easier to estimate potential SLR social ramifications.

SLR creates hydraulic pressures such as increased inundation levels, shoreline erosion and saltwater intrusion. Influenced by actors such as the government, socio-economic groups and investors, these hydraulic pressures combine with socio-economic pressures such as water pollution practices, inefficient consumption and damaged infrastructure to form stressors- a biophysical situation- that lead to water insecurity in terms of water quantity and quality. This insecurity can affect agriculture, livestock, fish industries, infrastructure/water services, and manufacturing, exacerbating water insecurity (Cai et al., 2016; Stoler et al., 2021). This, in turn, relates to SDM due to its adverse impact on livelihoods- Figure 5.

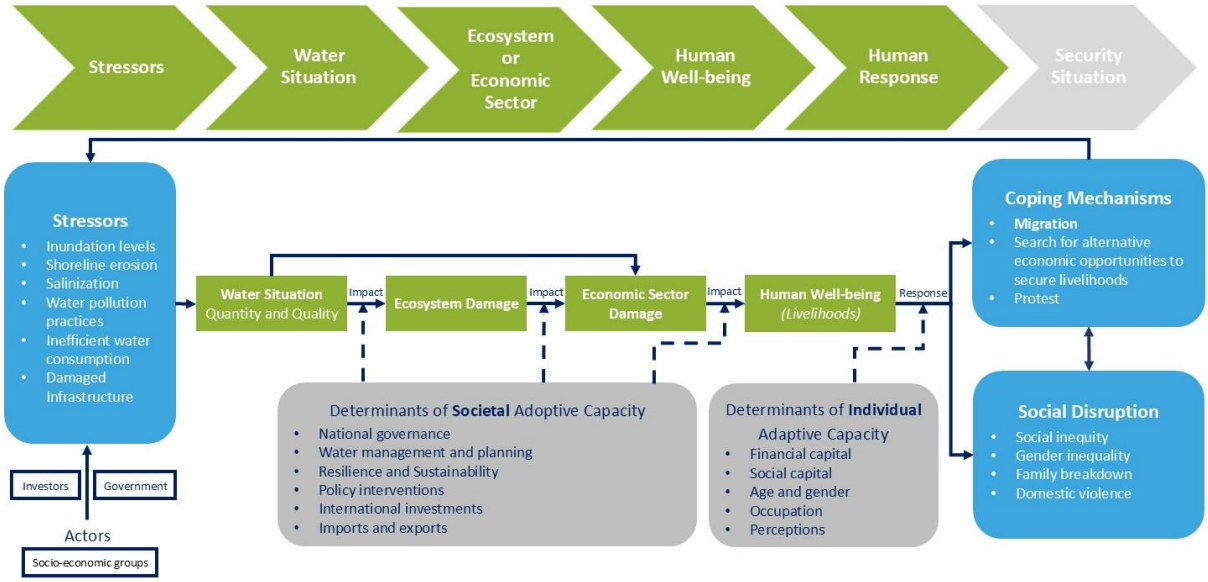


Figure 5 Framework of Analysis; Modified from (Mahmoud et al., 2023)

The ramifications of SLR can manifest across interconnected levels: ecosystems, economic sector, and human well-being Figure 5. At the ecosystem level, SLR can negatively impact agricultural lands, fisheries, surface water, and groundwater. These adverse impacts on the ecosystem level influence a country's socio-economic dynamics at the economic sector level. They can potentially lead to declines in manufacturing, agriculture, livestock, and fish industries, as well as water services. Additionally, they can cause asset losses, such as infrastructure deterioration or damage. Impacts on the economic sector, in turn, can affect individuals on the human well-being level, possibly resulting in insufficient household water and sanitation, health issues, reduced access to education, and income insecurity. For example, increased inundation levels and water pollution practices—both stressors—affect irrigation water quality and quantity, leading to the deterioration of agricultural lands, which is a form of ecosystem damage. This situation can cause asset losses and/or severely impact national food security and

employment rates, resulting in damage to the economic sector. This, in turn, reduces household food and income, negatively affecting human well-being.

Such reductions may prompt individuals to seek alternative economic opportunities, migrate, or engage in protests and riots as coping mechanisms (Mahmoud et al., 2023). Additionally, these impacts can intensify gender inequality, family breakdown, and domestic violence, leading to social disruption (Ha Noi, 2014; Leal & Huaman, 2019; Pommells et al., 2018)

Adaptive capacity, both at societal and individual levels, influences the impact of SLR on human well-being, i.e. the choice of specific coping mechanisms or the occurrence of specific forms of social disruption (Figure 5). Determinants of adaptive capacity, such as national governance, resilience, an individual's social and financial capital, culture and norms, age, and occupation, shape the impact severity and the coping mechanisms choice (Mahmoud et al., 2023).

While a response to SLR, migration isn't the only mobility-related ramification, non-migration is equally relevant, especially for vulnerable groups lacking the resources to migrate (Black et al., 2011). It is important to note that individual needs at the human well-being level can be met through avenues beyond national or local products. These channels may include aid, imports and international investments (Scheffran, Brzoska, Kominek, Link, & Schilling, 2012). Therefore, institutions, governance, and economic factors can shape the impact of SLR on SDM.

3.2 Methodology: From Hackathon Insights to Study Execution

The first part of the study is Preparation and the Event Activities- Figure 6. In the context of the SDM cross-domain aspect during the hackathon, two primary goals were established: (1) ensuring teams considered the social implications of their proposed measures, and (2) gathering as much insight as possible from the participants. To achieve this, the event activities were structured around the theoretical framework.

The framework was introduced interactively to help participants understand its components and relevance. This approach encouraged them to consider the social dimensions of their proposed measures and served as an entry point to highlight the potential linkages between SLR and SDM. As a result, interest in completing the questionnaire and interviews was increased, ensuring a deeper exploration of SLR-related SDM in this report.

First, a serious game was developed specifically for the hackathon. The game aimed to get the participants familiar with the social ramifications of SLR. It utilizes the theoretical framework to clarify the relationship between SLR and SDM. Each turn of the game revolves around a real-life example of an individual from an Egyptian community perceived to be vulnerable to SLR. Players gain insight into the broader context and challenges the community faces by drawing cards describing biophysical issues and mismanagement by authorities. Participants then make their first move by selecting from a list of coping mechanisms. They should choose the most realistic coping mechanism they believe the individual would employ. The Second move is to choose from another list an action for authorities to alleviate the situation. Moves are rated by peers based on realism, fostering discussions on the factors affecting individuals' choices of coping mechanisms and effective strategies to alleviate their situation. The game helps participants grasp and visualize the theoretical framework, enabling them to better understand the complex, interconnected, and context-specific factors driving SLR-related SDM. Further details on the serious game are available in Annex A.

To gain insights from the hackathon participants, the questionnaire and expert interviews were designed. Experts from the hackathon participants were selected for interviews based on the extent of

their on-ground experience working with communities. The interviews were structured to align with the flow of the theoretical framework, with questions designed to reflect its content. The interviews were implemented after participants played the game, which helped familiarize them with the framework's components, ensuring that their responses were informed and contextually relevant. The interviews balanced structured questions with open-ended dialogue. This approach allowed for flexible interviews, enabling the experts to elaborate on their insights and share information based on their expertise.

The questionnaire followed the same structure as the expert interviews but used multiple-choice questions. A total of 36 participants answered the questionnaire. Participants had the option to answer the questionnaire face-to-face, which most of them did. This allowed for elaboration and discussion and helped identify more experts for the interviews. A list of Participants in the questionnaire and further details on the questionnaire and expert interviews are available in Annex B and Annex C.

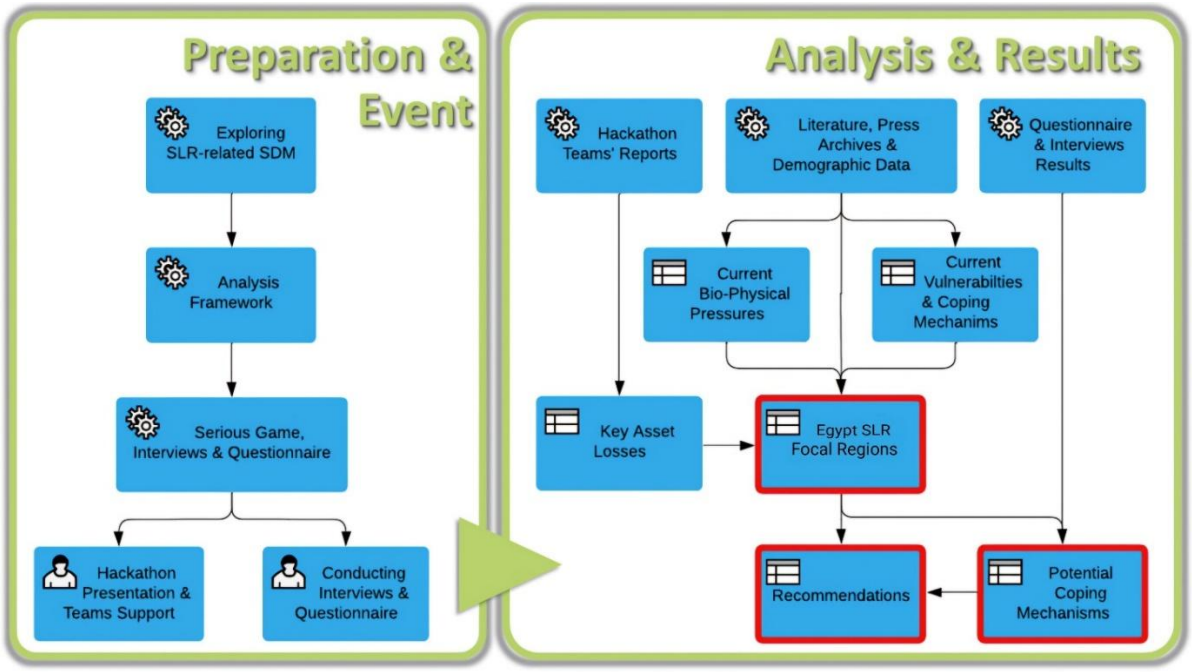


Figure 6 Diagram showing activities during the Hackathon and reporting stages

The second part of the study is Analysis and Results- Figure 6. It focused on executing rapid analysis, using the hackathon teams' reports, relevant literature and demographic data, and insights from the questionnaire and interviews. The analysis started with a review of relevant scientific literature, press archives, and demographic data. This review helped identify current demographics, social structure, biophysical pressures, vulnerabilities, and coping mechanisms. Next, the reports from the hackathon teams were examined to extract the flood extent maps and SLR scenarios and pinpoint significant asset losses. These asset losses, combined with the current situation, were used to identify Egypt's SLR focal regions of SDM—governorates with a high risk of experiencing SLR-related SDM. Flood extend maps and SLR scenarios were used to quantify potentially affected populations. Insights from the questionnaire and expert interviews were then used to explore potential coping mechanisms and the characteristics of those implementing them. Finally, recommendations for mitigation and adaptation strategies were developed based on these findings.

4 Egypt's North Coast and Delta: Pressures, Coping Mechanisms, and Disparities

4.1 Significance of the Area

As the most densely populated area in North Africa, Egypt's North Coast and Delta (Figure 7) support intensive agricultural and economic activities. The area is Egypt's economic power hub, although it constitutes a mere percent of Egypt's overall area. It contributes to over 50% of Egypt's economic activity, encompassing agriculture, industry, and fisheries (UNDRR, 2021). The agriculture, fisheries, and tourism sectors in the Delta alone constitute 20% of Egypt's GDP (UNDRR, 2021). The area is also home to major cities and economic centres such as Alexandria, Damietta and Port Said.

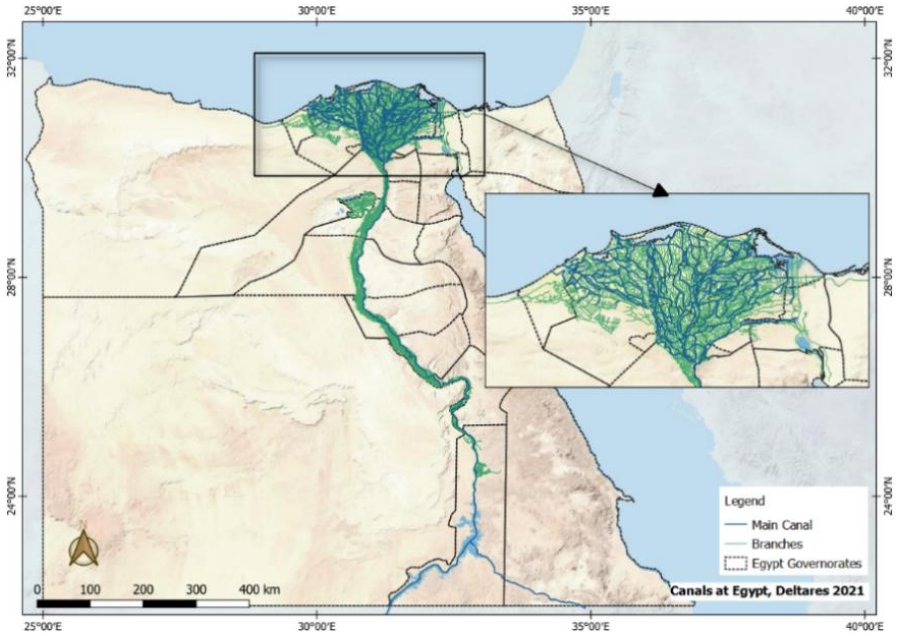


Figure 7 Egypt's North Coast and Delta; (IPDC, 2024)

The Nile Delta encompasses more than a third of Egypt's agricultural lands (Mounir, 2023a; Voiland, 2024) and supplies up to 60% of its total food production (Badreldin, Abu Hatab, & Lagerkvist, 2019). About 57% of Egypt's buffalo population is located in the Delta region (Fahim et al., 2018). The milk production from buffaloes constitutes around 47% of Egypt's total milk production, while cattle contribute 51% (FAOSTAT, 2016). Livestock plays a crucial role in Egypt's agricultural systems, with their products making up 40% of the value-added agriculture sector (Ahmed, Abdel-Salam, & Rungsuriyawiboon, 2020).

Correspondingly, the Nile Delta is a vital source of aquaculture. The fisheries and lakes in the region are major contributors to Egypt's Fish production. The region contributes to over 60% of Egypt's total fish catch (Mounir, 2023b). The capacity of Burullus Lake alone is estimated at 760,000 tons, representing up to 42% of Egypt's total fish production (GlobWetland Africa, 2022; Team Blue, 2024). In addition, the coastal lakes in the Nile Delta represent about 25% of the wetlands in the Mediterranean Sea (Mounir, 2023b). Lake Manzala and the Ashtoumaljamil Reserve alone host more than 200 species of resident or migratory birds (Team Blue, 2024).

Egypt's North Coast and Delta host major investments and urban developments. Particularly noteworthy is Port Said, which serves as a crucial entry point for commercial vessels traversing the Suez Canal to

and from Europe, Asia, and Africa. The canal facilitates 8 to 10 percent of global maritime trade, contributing approximately $5 billion in annual revenues to Egypt. Port Said has also diversified its developments, emerging as a leading producer of salt (Dooley, 2016).

Tourism and international investment significantly bolster Egypt's economy, yielding considerable annual dollar revenues and foreign currency returns. Recent government investments in Egypt's north coast and delta reflect high expectations for its economic potential. This is evidenced by major new developments such as New Rosetta, New Mansoura, New Damietta, and El-Alamein City.

4.2 Demographic Structure

Egypt's north coast and delta host more than 32 million people- about a third of Egypt's population (CAPMAS, 2023). The region hosts diverse and interconnected communities including farmers, fishermen, Bedouins and investors who are not necessarily living in the region but own land for investments. The exact percentages of each community were not identified, perhaps due to entanglement between different communities. This is most visible in the Delta, where residents might be farmers, yet work in fishing at specific times of the year. Similarly, many small business owners, public sector workers, and private sector workers work as farmers or fishermen besides their jobs (Al-Ragehy, 2024; Ali, 2024). However, it is acknowledged that the agricultural sector supports the livelihoods of 55% of the population and directly employs more than 30% of the workforce in Egypt (FAO, 2024a).

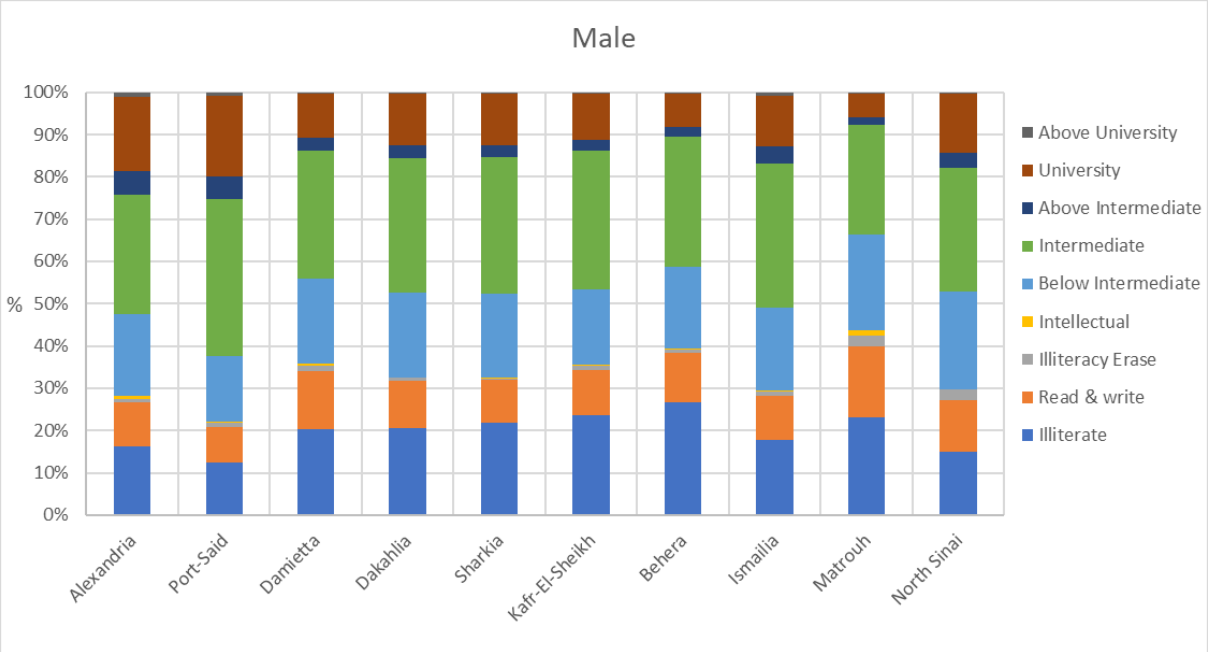


Figure 8 Men's Educational status; Data extracted from (CAPMAS, 2023)

According to statistics by the Central Agency for Public Mobilization and Statistics (CAPMAS), the demographic distribution in the governorates of the region exhibits near parity between males and females, with both genders comprising roughly equal proportions of the total population. The population has a predominantly youthful demographic profile- about 50% are aged 15-45 years old. Damietta, Dakahlia, Sharkia, Kafr El-Sheikh and Behera governorates are mostly rural. Alexandria and Port-Said governorates are almost completely urban. In contrast, Ismailia, Matrouh and North Sinai governorates have a balanced urban-rural distribution, with approximately equal proportions of rural and urban areas. The majority of the male population in the region has intermediate education (26%-37%), while a significant percentage is still illiterate. The percentage of illiterate men is most significant

in Beheira governorate, where 27% of men are illiterate. The education status of women in the region slightly varies. In Matrouh, Beheira, Kafr El-Sheikh and Sharkia governorates, women are mostly illiterate. In Alexandria, Port Said, Damietta, Dakahlia and Ismailia governorates, most women have intermediate education. More details about the education status in governorates are in Figure 8 and Figure 9.

Marital status[5] is to an extent similar in all governorates of the region. Married people account for roughly 60% -75% of the population, while the majority of the remaining percent have never married before- 20%- 30% (CAPMAS, 2023).

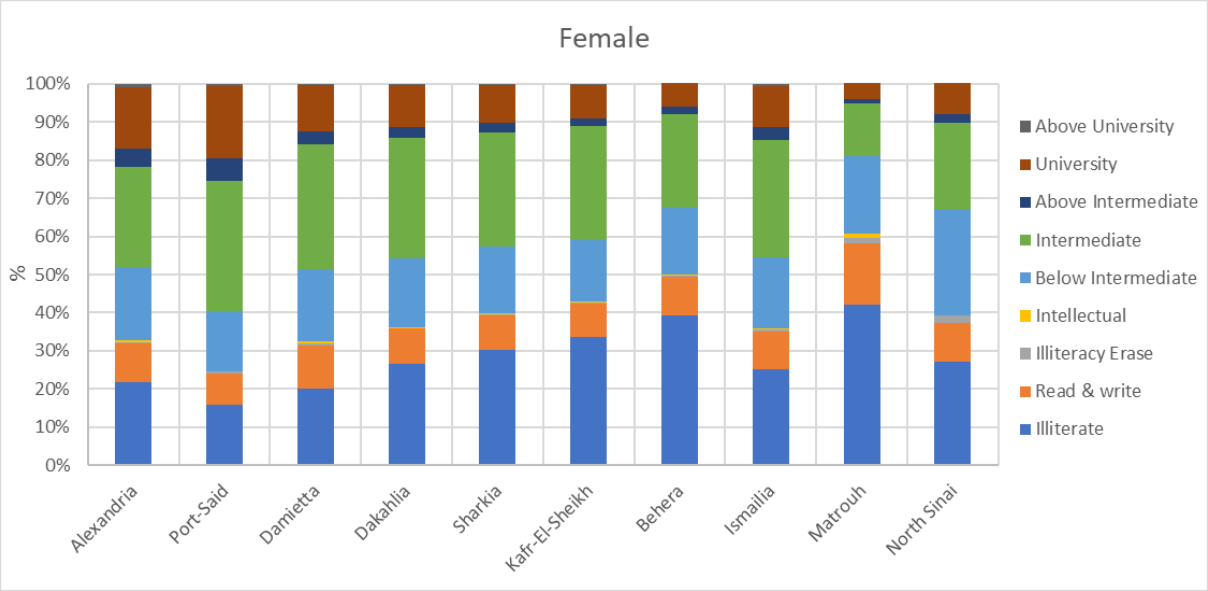


Figure 9 Women's Educational status; Data extracted from (CAPMAS, 2023)

4.3 Current Biophysical Pressures

Experts indicate that SLR has become evident in Egypt's north coast and delta, with its impacts manifesting over the years. SLR has caused sudden extreme events like flash flooding and coastal inundation. In parallel, SLR causes gradual phenomena like coastal erosion, salt intrusion into freshwater and soil salinization. Currently, the Governorates most affected by SLR are Alexandria, Beheira, Damietta, Dakahlia and Kafr El-Sheikh. However, Kafr El-Sheikh governorate is experiencing the most dramatic effect (Mounir, 2023a).

Roughly 50% of the SLR affecting the Nile Delta is attributed to global warming, with the remaining portion attributed to natural processes like land subsidence, as well as human activities such as excessive groundwater extraction and oil production (Voiland, 2024). Land submergence in the area spans from 0.4 mm per year in the western Delta and 1.1 mm per year in the central Delta to 3.4 mm per year in the eastern Delta (IPCC, 2021), surpassing the global average of 1.8 mm/year (Jevrejeva, Moore, Grinsted, Matthews, & Spada, 2014). In some areas, satellite imagery shows that the coastline has retreated more than 840 meters from 1985 to 2024- Figure 10.

SLR interacts with (exacerbates and is exacerbated by) existing manmade and natural challenges such as pollution, urban expansion, and water scarcity. For Instance, urban areas in Kafr El-Sheikh governorate have expanded from 138.6 km^2 in 1990 to approximately 224 km^2 in 2023 (Mounir, 2023a), while the

[5] Calculated by CAPMAS for residents over 18 years old.

governorate is located on the outskirts of the delta, a region significantly affected by the natural phenomenon. The resultant effect has already caused excessive saltwater intrusion into freshwater sources and the widespread salinization of agricultural land (Abou-Mahmoud, 2021; ElSafty & Saafan, 2022; Hammam & Mohamed, 2020).

Figure 10 Satellite images showing the change in the coastline from 1985 to 2024 (Source: Google Earth, 2024)

Approximately 15 percent of Egypt's most fertile agricultural land has already been adversely affected (FAO, 2024b), while crop and livestock losses in the Delta region have reached 30-40% (UNDP, 2023). Local communities confirm incidences of submergence of homes, local facilities and tens of feddans of agricultural lands. In 2023 alone, more than 13 km^2 were submerged. In the winter seasons, sea levels rise dramatically in some villages, causing serious damage to crops, with extreme consequences in some occurrences. In 2020, rice production in Kafr El-Sheikh governorate plummeted to zero, contrasting starkly with the approximately 2,400 tons harvested in 2010 (Mounir, 2023a).

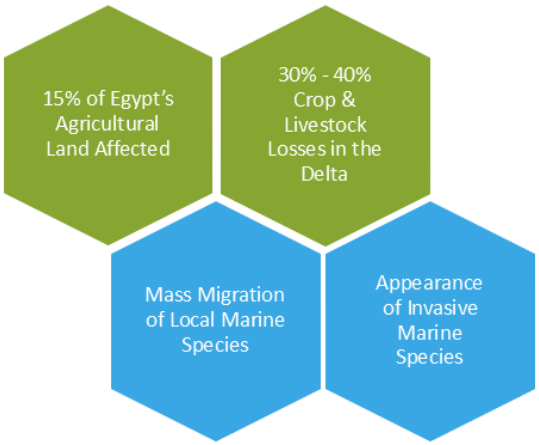


Figure 11 Current Biophysical Pressures

Moreover, changes in salinity levels attributed to SLR (and climate change) lead to the migration of local marine species, especially fish, to other areas where they can survive. It also leads to the appearance of invasive marine species that deteriorate the marine environment and threaten the remaining local species. Local fishermen indicate that many fish species have disappeared and were replaced by others that are small-sized and unsuitable for consumption (Al-Ragehy, 2024; Mounir, 2023a). The consequences are evident in the fish production reports by CAPMAS, which indicate a 3% reduction in freshwater fish production and a notable 23% decline in Mediterranean Sea fish production (CAPMAS, 2010, 2020).

4.4 Current Vulnerabilities

4.4.1 *Flooding*

Over the past decade, press archives have been overloaded with numerous flooding incidents. Between 2015 and 2018, coastal erosion damaged Al-Hamad, Al-Shahabiya, and Umaira Al-Sharqiya villages in Kafr El-Sheikh Governorate. Residents appealed for help, citing submerged agricultural lands and damaged homes. Similarly, three years later, residents of Baltim City in Kafr El-Sheikh Governorate faced flooding due to 7-meter high waves from the Mediterranean Sea (Mounir, 2023a). In an interview with the Thomson Reuters Foundation, fishermen of Mastroua village, northern Kafr El-Sheikh, said that flooding has become inevitable every winter. They stated that SLR has destroyed homes, and flooded agricultural lands and roads. As a result, fishermen's income decreases by 70% every winter (Farouk, 2022).

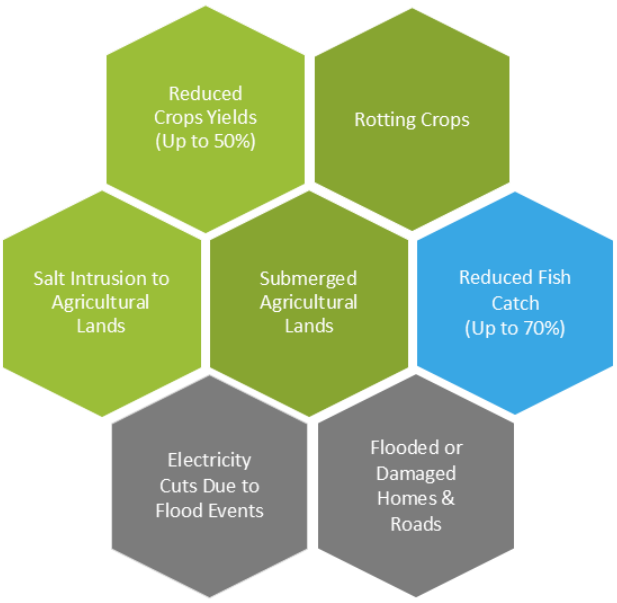


Figure 12 Current Vulnerabilities

In Ras El-Bar, Damietta, SLR surpassed 10 meters during a storm event in 2018. Consequently, homes were destroyed and electricity was cut (Abdelbary, 2018). During the hackathon event, an interview with the Emergency Service Director of Egypt's Ministry of Water Resources and Irrigation (MWRI) confirmed that destructive floods in Damietta and Kafr El-Sheikh have become increasingly frequent over the past decade (Blata, 2024). In 2015, the government evacuated hundreds of residents due to heavy rains and SLR flooding the entire Al Max neighbourhood in Alexandria (Aldekoa & Aragó, 2023).

4.4.2 *Saltwater intrusion*

In respect of its slow-onset threats, SLR is visibly impacting the local communities by threatening agricultural lands and livestock and endangering homes. Interviews with farmers in Burullus City, Kafr El-Sheikh have reported extreme saltwater intrusion into their agricultural lands since 2011 (EL-Attar, 2023). Across Kafr El-Sheikh Governorate, farmers reported that soil salinity sometimes reduces their crop yields by up to 50% (Mounir, 2023a). In Ezbet El Bus, Alexandria, farmers reported that for the past five years, their crops have been rotting due to high levels of soil salinity (Aldekoa & Aragó, 2023). Similarly, a senior researcher from the National Water Research Centre (NWRC) mentioned during an interview at the hackathon event that her fieldwork in Beheira and Dakahlia governorates revealed numerous farmers experiencing significantly decreased crop yields. The issues were attributed to SLR-related problems such as saltwater intrusion and soil salinization (Ali, 2024).

The case is also similar for fishermen. During an interview conducted during the hackathon with the general manager of Water Quality and Lakes at the Egyptian Ministry of Environment (EEA), it was highlighted that small-scale fishermen typically possess equipment tailored for specific types and sizes of fish[6] and often lack the capital to acquire new gear. To sell their fish catch, these fishermen primarily rely on connections with merchants or shop owners who specialize in selling specific types of fish and

[6] To catch specific types of fish, fishing nets must have particular mesh sizes, wire diameters, and materials.

would not buy different fish types even if fishermen were able to catch them. Salt intrusion attributed to SLR has disrupted water quality, leading to changes in the availability and sizes of fish species, significantly impacting many fishermen (Al-Ragehy, 2024).

4.5 Current Coping Mechanisms

4.5.1 *Farming adaptation*

As documented in several media reports, residents have resolved to different coping mechanisms. Many farmers in Damietta and Kafr El-Sheikh governorates have transitioned from growing tomatoes, cucumbers, melons, and pineapples to more resilient crops like cotton, beetroot and rice due to the increasing salinity of the soil. Despite resilient crops being less profitable, their cultivation helps cleanse the soil of salt through irrigation (ElSafty & Saafan, 2022; Mounir, 2023a). In Alexandria Governorate, most farmers have experienced crop losses over the past five years due to increasing soil salinity. As a result, many have stopped growing fruits and vegetables and switched to more resilient crops or pursued non-agricultural economic opportunities like fishing in the Mediterranean Sea (Al-Ragehy, 2024; Aldekoa & Aragó, 2023). Others have transitioned from agriculture to aquaculture (EL-Attar, 2023).

Figure 13 Current Coping Mechanism

The current situation forces many farmers in Egypt's north coast and delta to double the number of seeds and apply additional fertilizer in an attempt to reach the usual crop yields. It has also forced farmers to use heavy machinery and chemical fertilizers to enhance productivity, exacerbating soil degradation (Aldekoa & Aragó, 2023; EL-Attar, 2023; ElSafty & Saafan, 2022; Mounir, 2023a)..

This situation has resulted in a doubled workload for farmers. To cope with domestic responsibilities (particularly for women) and the growing agricultural challenges caused by current biophysical stressors, many farmers have formed a system where they work together in each other's fields (Joshi, Dessouki, & Lahham, 2022)

Nonetheless, productivity continues to lag behind expectations, while the situation deteriorates yearly. As a result, many farmers with tenancy agreements seek alternative economic opportunities such as seeking out new plots for cultivation and exploring opportunities with new landlords (Aldekoa & Aragó, 2023; EL-Attar, 2023; ElSafty & Saafan, 2022; Joshi et al., 2022; Mounir, 2023a).

4.5.2 *Adaptation in Fisheries*

Correspondingly, the situation has forced many fishermen to seek new fishing locations as noted in the hackathon interviews and press archives. Many have had to venture into deeper waters, sometimes beyond Egyptian borders (Al-Ragehy, 2024). In 2021, nearly 120 fishermen were detained, and their ships were seized by Eritrea. Just weeks earlier, Saudi Arabia had released 35 fishermen who were

arrested for fishing illegally in its territorial waters, and Tunisia seized two Egyptian boats carrying dozens of fishermen near its borders (Egypt Today, 2021a, 2021b, 2021c).

Residents in severely vulnerable areas have migrated in search of job opportunities (Mounir, 2023a). For instance, several villages near Port Said, which provide jobs for both Mediterranean fishermen and fish farmers on Lake Manzala, have experienced a 50% population decline over the past ten years (Ferrando, 2023). Most Significantly, a village along Manzala Lake saw a population decline from 100,000 residents in 2010 to 45,000 individuals in 2020. Approximately 90 percent of the residents were fishermen, but many had to migrate to look for alternatives (Ferrando, 2023).

4.6 Social Disruption & Vulnerability Disparities

The Situation in Egypt's northern coast and delta has already prompted significant social disruption, worsening existing vulnerabilities. Adapting to these new conditions requires substantial resources, such as additional fertilizers, machinery, or equipment to venture into deeper waters- costs many villagers cannot afford. Consequently, they must rely heavily on personal efforts, connections, and financial capital, leading to resource capture and increased social inequality. This situation creates a cycle that drives more farmers and fishermen to seek alternative or additional economic opportunities. As more farmers resort to fishing in the Mediterranean Sea or other areas and fishermen change their fishing locations, conflicts have arisen between them and local fishermen, exacerbating tensions and causing conflicts (Al-Ragehy, 2024; Ali, 2024).

Many fishermen, lacking the proper equipment, are compelled to fish in deep waters. This not only makes their job more difficult but also significantly jeopardizes their safety- endangering the safety of low-income individuals. Extended fishing trips mean that household heads are often away from home for long periods, leaving the remaining adult family members—typically women—to handle all household responsibilities alone. This situation leads to family breakdown while increasing stress and workload, which can lead to mental and physical health issues (Team Blue, 2024) and intensify gender Inequality. Additionally, the need for extra income forces younger family members to seek work, which can negatively impact their education and health if they work long hours. Furthermore, their job insecurity often leaves them vulnerable, as they may avoid asserting their work rights for fear of losing their jobs (Al-Ragehy, 2024; Ali, 2024).

In a project by the Consultative Group on International Agricultural Research (CGIAR), a case study analysis was conducted with farmers in the polluted Kitchener Drain (also known as Drain Number 7). The drain passes through Kafr El-Sheikh and Dakahlia both among the most affected governorates by SLR-related issues. The combination of water scarcity and pollution, low productivity, and health risks associated with cultivating these plots has led the owners to sublet land on tenurial sharecropping arrangements to landless households. Unfortunately, tenant farmers are

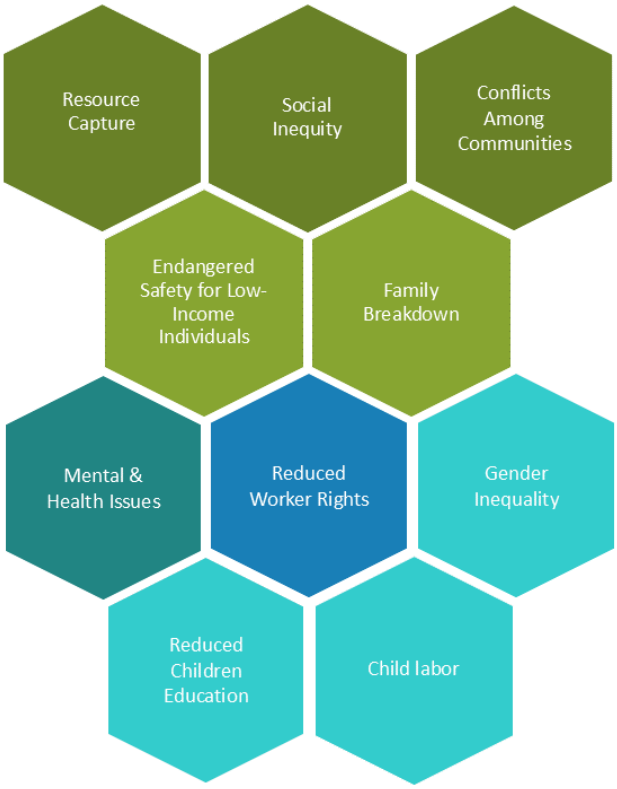


Figure 14 Social Disruption & Vulnerability Disparities

excluded from accessing extension services, training, loans, credit facilities, agricultural cooperatives, and water user associations, as membership requires being a registered landowner (Joshi et al., 2022).

Despite the tenancy agreements typically being in the names of their husbands, it is often women who serve as the primary farmers and irrigators on these plots. One case study highlights a woman who bears sole responsibility for all agricultural tasks on a feddan of land rented by her husband under a sharecropping arrangement. At 30 years old with two children, she married her 75-year-old husband at the age of 17. Despite her health challenges, including bone marrow cancer for which she cannot afford treatment, she continues to care for her sick husband and son. Illiterate and unaware of her cropping share, she must rely on the landowner's decisions regarding sub-letting. Apart from selling a small portion of her crops, her only source of daily income is derived from the cow owned by her landowner (Joshi et al., 2022).

Numerous studies, reports, and interviews have highlighted social disruption and vulnerability disparities in Egypt's North Coast and Delta. However, the specific role of SLR in particular instances remains significantly understudied. As discussed in Section 2.3, the complex, interconnected, and contextual factors driving SLR-related SDM make it extremely challenging to isolate SLR as the sole driver of specific SDM cases. Instead, it is more accurate to view SLR as a contributing factor, with its exact degree of influence uncertain due to the complexity of the phenomena and the lack of robust evidence.

4.7 Recap: Egypt's North Coast and Delta as a Potential Model for the SLR-SDM Framework

In Egypt's North Coast and Delta, we witness a situation analogous to the framework explained in Section 3.1. Stressors such as coastal inundation and erosion, salinity intrusion, pollution practices, and urban expansion have led to an insecure water situation (IPCC, 2021). This situation has caused damage to the ecosystem including losses in agricultural lands, livestock, and local marine species (Al-Ragehy, 2024; FAO, 2024b; UNDP, 2023). It further led to economic damages including reduced crop yields and fish catch (CAPMAS, 2010, 2020; EL-Attar, 2023; Mounir, 2023a) in addition to occasional damages to homes and roads and electricity cuts in case of extreme events (Abdelbary, 2018; Aldekoa & Aragó, 2023; Mounir, 2023a). In turn, insecurities in water, food and income lead individuals to resort to coping mechanisms such as migration and seeking alternatives. Press archives and expert interviews have confirmed that many farmers in the region are already doubling seeds and fertilizers, shifting to more resilient crops, and using heavy machinery and chemical fertilizers. Many resort to aquaculture instead of agriculture while others seek alternative economic opportunities in their hometowns or migrate internally or externally (Al-Ragehy, 2024; Aldekoa & Aragó, 2023; ElSafty & Saafan, 2022; Mounir, 2023a). Furthermore, the situation exacerbates and is exacerbated by many forms of social disruption manifested in social inequity, gender inequality and family breakdown (Al-Ragehy, 2024; Ali, 2024; Joshi et al., 2022).

Although the impact of SLR on the social stability and economy of Egypt's North Coast and Delta has likely been secondary to other factors thus far, its future impact could be severe. SLR will further deplete already scarce resources, such as freshwater and arable land, exacerbating existing challenges in a region already under significant strain (Clement et al., 2021). This resource reduction could intensify critical socio-economic pressures, amplifying vulnerabilities and potentially destabilizing the region further. Comprehensive studies that thoroughly investigate this context, including projections of future impacts, the evolution of coping mechanisms, and the extent of social disruption are urgently needed.

5 Exploring Future Vulnerability in Egypt's North Coast and Delta

5.1 General

The analysis presented hereafter is based on the findings from the hackathon, which relied on rapid assessments and expert judgments across several areas. As such, the results should be considered indicative rather than precise, given the exploratory nature of the hackathon's approach in addition to the complex, interconnected, and contextual factors driving SDM.

This report's findings represent an initial attempt to quantify and explore connections in a largely unexplored and insufficiently researched area (Hauer et al., 2020), acknowledging the inherent uncertainties and limitations. Potential SLR impacts on SDM in Egypt remain an uncharted area. The report's greatest value lies in the insights gained during the analysis, such as understanding coping mechanisms, identifying who implements them, and determining where and why they are applied.

While current uncertainties remain, future research will likely clarify these aspects as SLR and its impacts unfold. The findings offer a foundational perspective, paving the way for more detailed and comprehensive studies in the future.

Section 5.2 defines and clarifies the study area for the subsequent analysis in the report. This is essential given the progressive and complex nature of the phenomenon under examination, which involves interconnected impacts, including both direct and slow-onset impacts. Section 5.3 summarizes key asset losses due to SLR to highlight the potential large-scale damage. Within the analytical framework outlined in Section 3.1, quantifying key asset losses is an initial step in linking SLR to its social ramifications. This conceptual linkage connects the biophysical phenomenon of SLR to its economic and, in turn, social impacts, including SDM-related effects on livelihoods and the resulting communities' coping mechanisms. The intent is to help readers envision and comprehend the potential connections between SLR and SDM, fostering a deeper understanding of these intertwined dynamics.

Following, to map vulnerable populations in directly affected regions by 2100, a combination of the flood extent maps and scenarios from the hackathon teams' reports and demographic and spatial data is utilized via GIS, as detailed in Section 5.4. This analysis, despite its simplified cause-and-effect narrative and the exclusion of SDM due to prior slow-onset impacts of SLR, identifies the forefronts of SLR-related SDM in Egypt's North Coast and Delta- Egypt's SLR Focal regions. It identifies the most vulnerable governorates and rough estimates of the affected population. Aligning with the theoretical framework, this analysis forms a foundation for understanding and quantifying the coping mechanisms employed in response to the impacts of SLR on livelihoods.

Chapter 6 builds on this using the questionnaire, expert interviews, and supporting literature to quantify future individuals' coping mechanisms. The methodologies in Chapters 5 and 6, combined with the current situation in Egypt's North Coast and Delta discussed in Chapter 4, clarify potential SLR focal regions for SDM. This aligns with the theoretical framework and unfolds the key links between SLR and SDM in Egypt.

5.2 SDM Impact Zones of SLR

The report employs a range of methodologies to assess SDM resulting from SLR along Egypt's North Coast and Delta. Drawing from the Hackathon's modelling outputs, the report projects affected populations and their coping mechanisms under 0.5, 1.0, 1.5, and 2.0-meter SLR scenarios by 2100.

The report categorizes the potentially affected regions into four distinct areas: 1) areas directly affected seasonally or perennially by 2100, 2) areas with deteriorated lands or services by 2100 in Egypt's North Coast and Delta, 3) the remaining areas of Egypt, and 4) surrounding countries that could potentially be impacted (Figure 15).

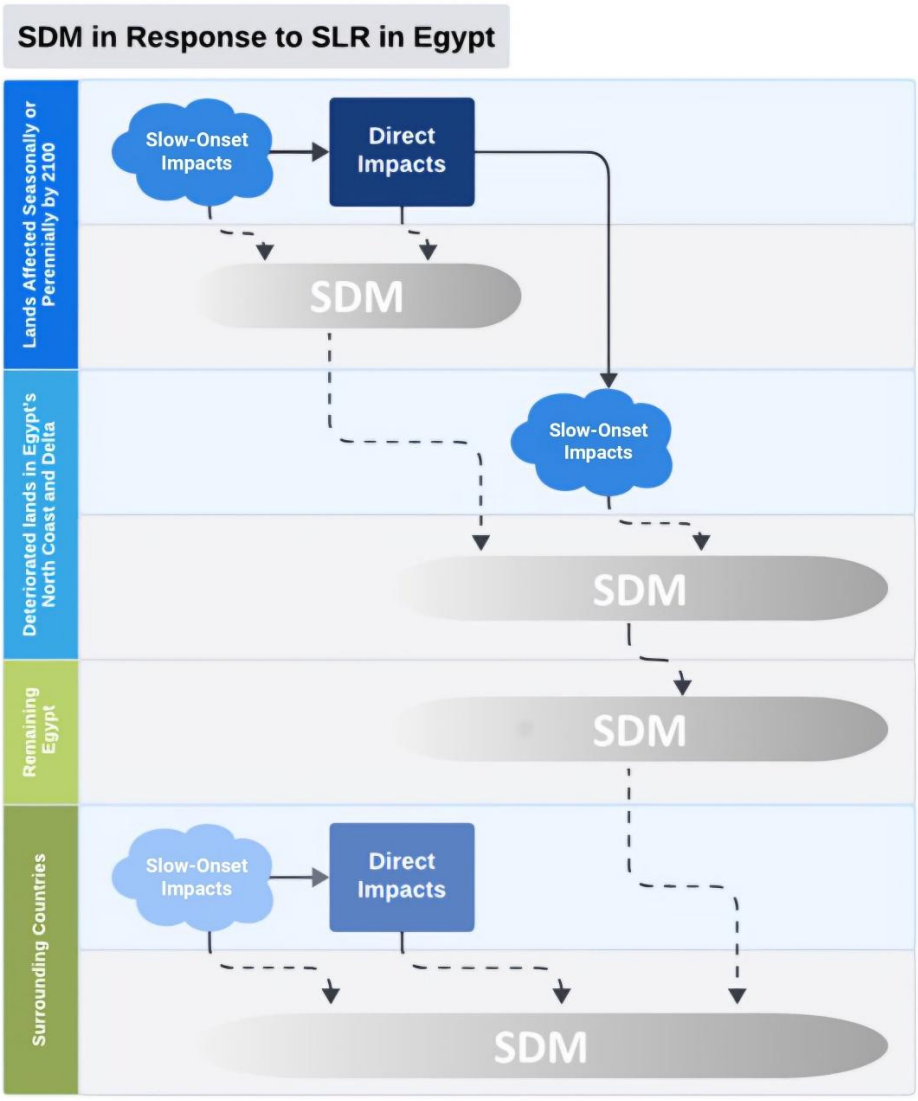


Figure 15 SDM Impact Zones of SLR

Given that the hackathon focused on the most vulnerable areas in Egypt's North Coast and Delta, and because mitigating SLR-related SDM in this area will likely mitigate SDM in the remaining regions, most of the report's findings revolve around areas directly affected seasonally or perennially by 2100. However, supporting analysis is included to discuss the key potential SDM that could spread to the subsequent areas.

5.3 Key Asset Losses

According to the recent IPCC report, about 2,660 km^2 are projected to be fully submerged by the year 2100 (IPCC, 2021). The repercussions will impact agricultural lands, fisheries, and vital infrastructure, including roads, power and water utilities, hospitals, and schools.

If no measures are taken to mitigate the impacts of SLR, predictions suggest that by 2050, the effects of climate change will significantly reduce crop yields. The prevailing projection anticipates that agricultural land will decrease by 17% (Mounir, 2023b), leading to an estimated 6% decrease in Egypt's total food production. More specifically, forecasts anticipate a 15% decline in wheat production (UNFCC, 2015), a 22% reduction in maize production, and approximately a 24% drop in pulses production (Perez et al., 2021).

Figure 16 Key Asset Losses

By 2100[7], it is predicted that a total of 8550 km^2 will be affected seasonally or perennially. Analysis performed during the hackathon event indicates that approximately 50% of the affected area will be agricultural lands (Team Grey, 2024). The losses in agricultural lands could surge up to 33% of the total agricultural lands in Egypt (Mounir, 2023b). Twenty-five percent of the affected lands will be fish ponds. The majority of the remaining affected area will be built up (Team Grey, 2024). Notably, losses in rice production may reach 1.4 million tons/ year (Team Green, 2024). This number is equivalent to more than 30% of Egypt's total rice production in 2021 (Statista, 2024a). Losses in wheat may reach 1.2 million tons/ year (Team Green, 2024), corresponding to 13% of Egypt's total production in 2021 (Statista, 2024a).

Affected vital infrastructures will be significantly prominent and diverse. More than 68% of the current water plants in the area will be fully flooded and more than 67% of the current wastewater treatment plants will be affected (Team Blue, 2024). The projected damage will also affect pumping stations with an estimated 70% per ESL event (Team Green, 2024). Additionally, more than 35 % of hospitals in the area will be affected (Team Grey, 2024)[8].

Vital economic developments will be significantly affected as well. A recent study on the vulnerability of tourism in EL Alamein reveals that 46% to 49% of the resorts in the area will be inundated by 2100 (El-Masry, El-Sayed, Awad, El-Sammak, & Sabarouti, 2022). Another study on Alexandria reveals that 36 hotels will be affected. The significance of the impacts will depend on the applied adaptation measures,

[7] Data is based on the raster results estimated from the SFINCS model conducted by Deltares.

[8] Most of the forecasts mentioned herein are derived from analyses conducted by teams participating in the Egypt SLR Hackathon Event.

yet 4 of those hotels are at high risk of complete inundation (Abou Kamar, Aliane, Elbestawi, Agina, & Alsetoohy, 2023). Furthermore, some historical and cultural heritage sites such as the Citadel of Qaitbay, the Catacombs of Kom el Shoqafa, Pompey's Pillar, the Roman Theatre, and the site of the ancient Lighthouse of Alexandria will be directly exposed to the flooding due to their proximity to the Mediterranean sea (Team Grey, 2024).

5.4 Mapping Affected Communities

To map communities vulnerable to SLR in Egypt's North Coast and Delta, the flood extent maps of the affected areas due to 0.5-, 1.0-, 1.5-, and 2.0-meter SLR by 2100 were analyzed and approximate lines representing each scenario were drawn. These scenarios identify governorates projected to be directly affected by SLR in 2100. Governorates include Alexandria, Beheira, Dakahlia, Damietta, Ismailia, Kafr El-Sheikh, Matrouh, North Sinai, Port Said, and Sharkia (Figure 17).

At first glance, it's evident that the Damietta and Port Said governorates are extremely vulnerable, being 100% affected under the 2.0- and 1.5-meter SLR scenarios. Port Said remains highly vulnerable with approximately 80% affected under the 1.0-meter SLR scenario, but its vulnerability decreases significantly under the 0.5-meter SLR scenario. In contrast, Damietta is minimally affected in the 0.5- and 1.0-meter SLR scenarios. Dakahlia and Kafr El-Sheikh governorates are approximately 50% affected under the 2.0-meter SLR scenario, the impact decreases substantially in the 1.5-meter SLR scenario and nearly disappears in more conservative scenarios. Less than 20% of Beheira, Ismailia, and Sharkia are affected in all four scenarios, while the impacts on Matrouh and North Sinai are negligible across all scenarios. The affected areas in Alexandria remain almost constant across all four scenarios. About 25% of the governorate's total area is affected.

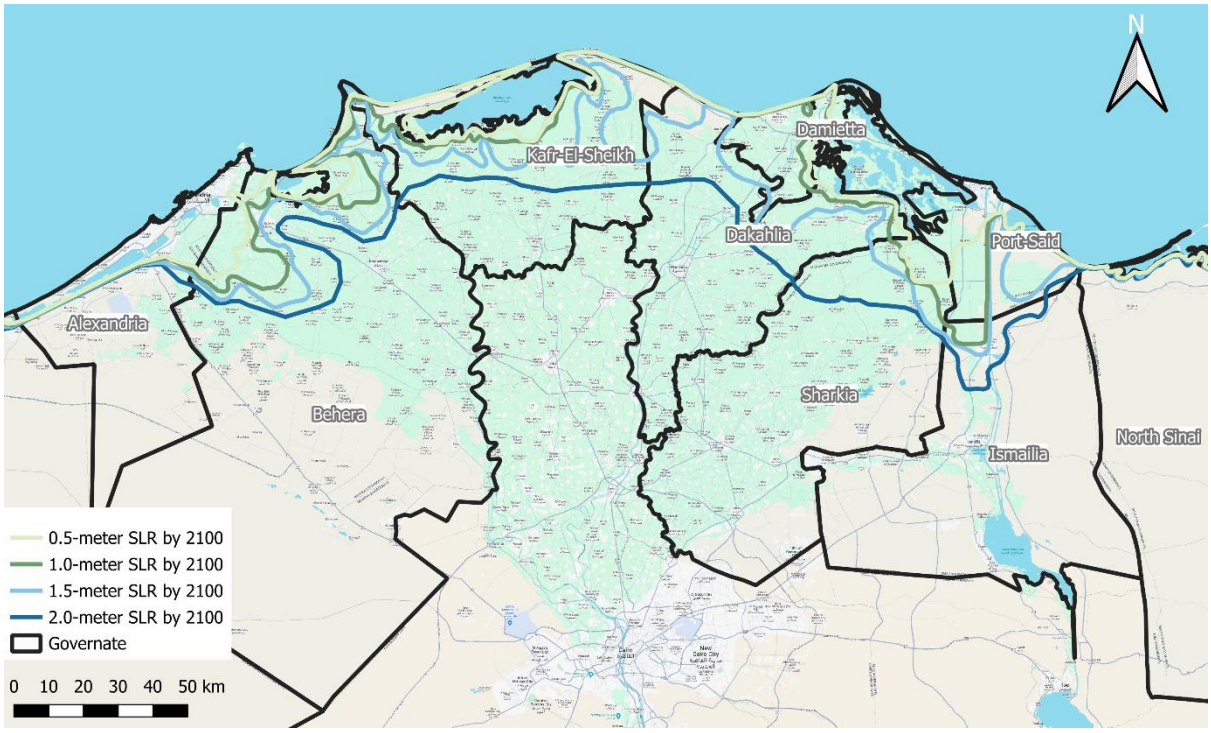


Figure 17 Map of Nile Delta including flood extent

Nevertheless, population densities within and between governorates vary significantly; some areas are densely populated while others have fewer residents. This variation means that even within a single governorate, there can be stark differences in population densities.

This report uses the population data provided by CAPMAS at the Markaz/Qism level to capture this variation. Markaz and Qism are subdivisions inside Egypt's Governorates in urban and rural areas respectively (CAPMAS, 2023).

Markaz/Qism level populations were extracted from the CAPMAS population estimates reports and loaded on GIS. Subsequently, affected subdivisions were identified and categorized as 100%, 80%, 60%, 40%, 20%, or 0% affected. Based on these categories, four scenarios of the total number of people per governorate residing in affected areas due to 0.5-, 1.0-, 1.5-, and 2.0-meter SLR by 2100 was estimated (Figure 18). Subsequently, the average population growth rates were calculated using the population estimates provided by CAPMAS for each governorate from 2006 to 2017. These growth rates were then used to forecast the number of residents in the affected areas.

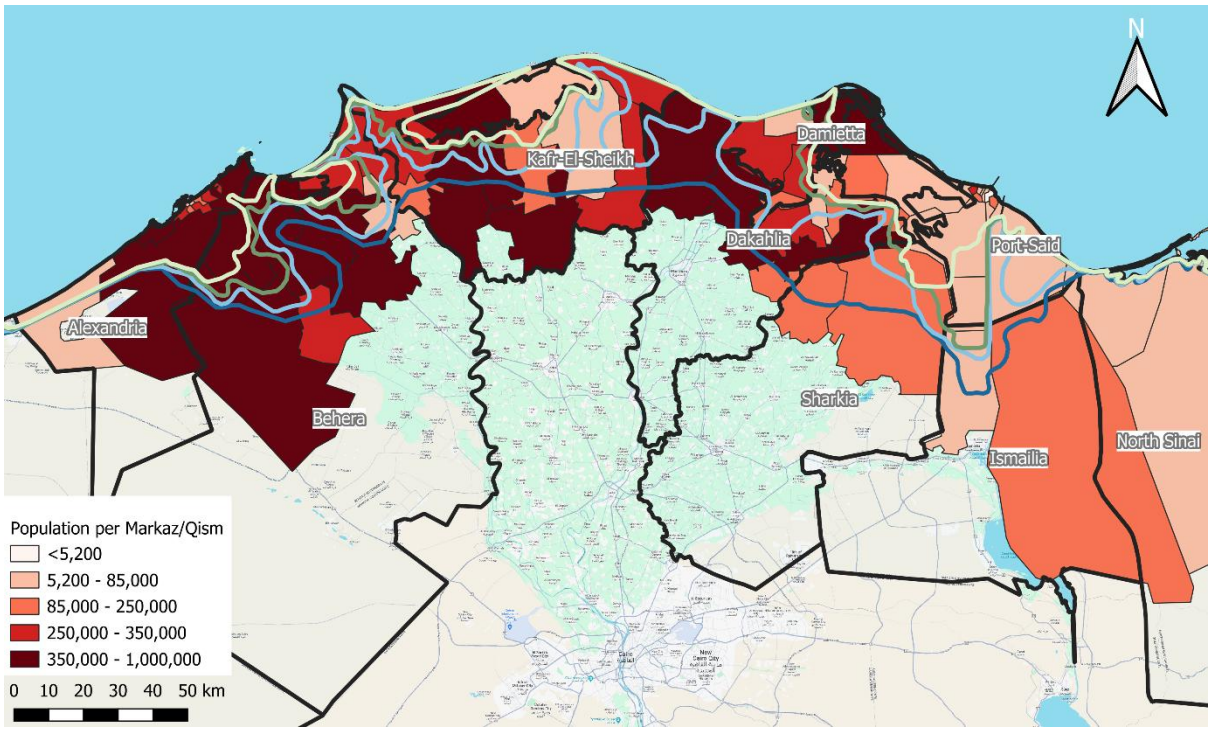
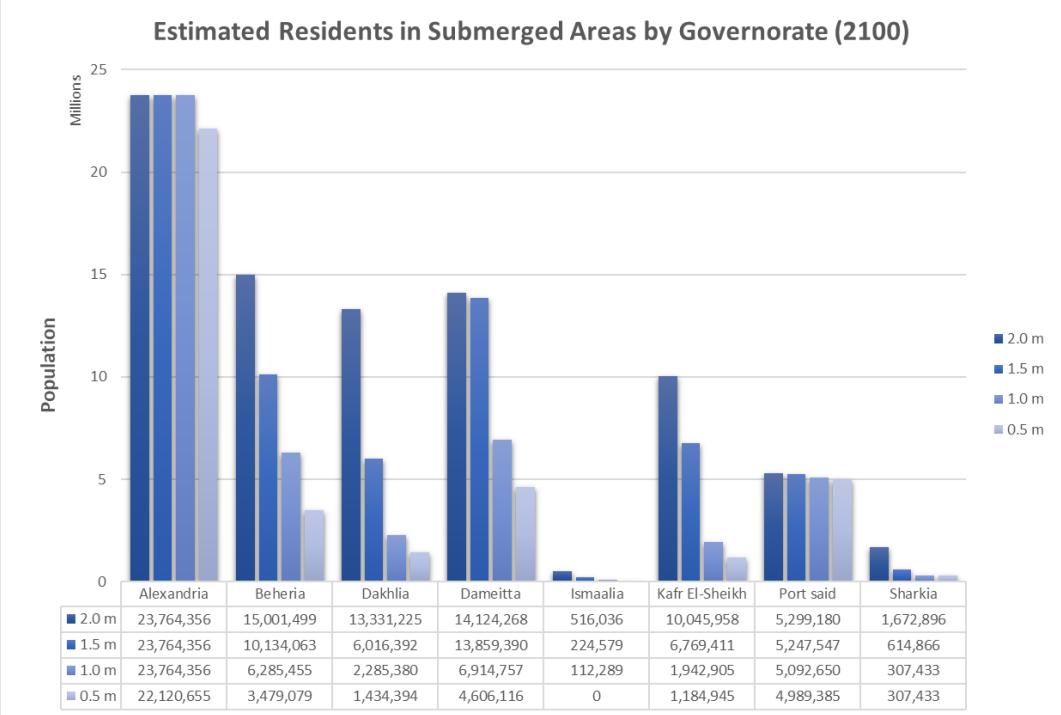


Figure 18 Map of Residents in Affected Governorates

If the 2-meter SLR scenario occurs by 2100, 84 million residents will be affected. In the 0.5-, 1.0-, and 1.5-meter SLR scenarios, the number of affected residents decreases to 67 million, 47 million, and 38 million, respectively (Figure 19).

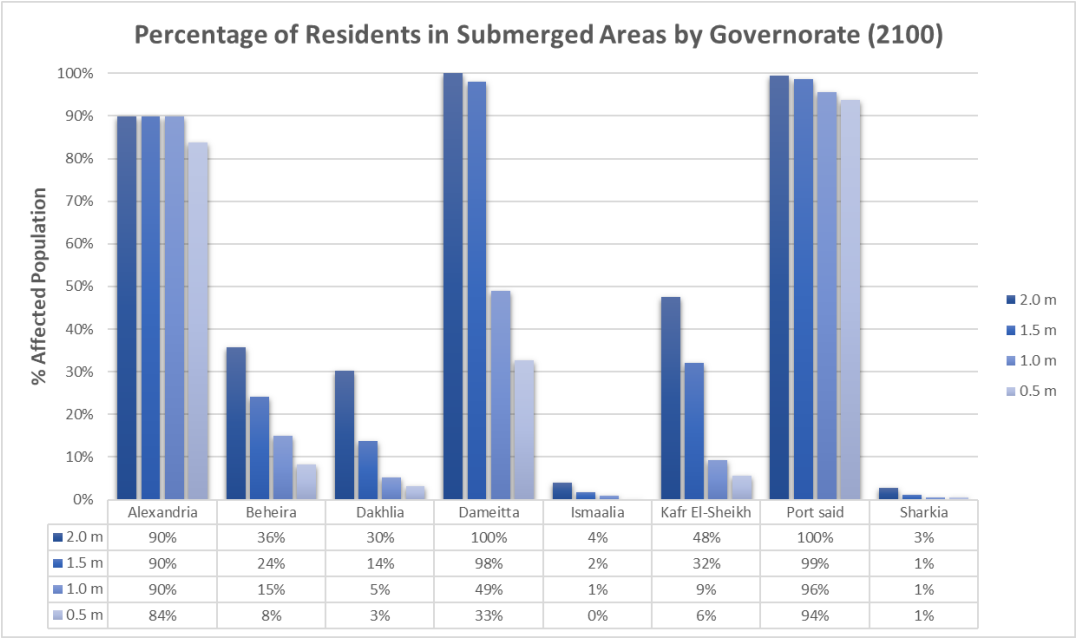
Despite not having the largest affected area, Alexandria is noteworthy because it accounts for about 24 million residents in affected regions, representing 35% of the affected population under the 2-meter scenario. Moreover, the affected areas of Alexandria remain nearly constant across the 1.0-, 1.5-, and 2.0-meter scenarios, with only a slight decrease in the 0.5-meter scenario. This stability results in Alexandria comprising 44%, 60%, and 66% of the affected residents in the 1.5-, 1.0-, and 0.5-meter scenarios, respectively- see Figure 19 and Figure 20.

By 2100, under the 2-meter SLR scenario, Beheira, Damietta, and Dakahlia governorates will have 15 million, 14 million, and 13 million residents in affected areas, respectively. These numbers account for 17%, 12%, and 15% of the affected population in this scenario respectively. However, in the 0.5-, 1.0-, and 1.5-meter SLR scenarios, the percentages decrease significantly for Beheira and Dakahlia. In contrast, Damietta's percentage remains relatively constant in the 1.5-meter SLR scenario before it too decreases significantly in the remaining scenarios. Having accounted for less than or equal to 2% of the residents in affected areas each, Ismailia and Sharkia governorates could be considered insignificant to studying SDM in Egypt's North Coast and Delta (Figure 20).



	Alexandria	Beheria	Dakhlia	Dameitta	Ismaalia	Kafr El-Sheikh	Port said	Sharkia
2.0 m	23,764,356	15,001,499	13,331,225	14,124,268	516,036	10,045,958	5,299,180	1,672,896
1.5 m	23,764,356	10,134,063	6,016,392	13,859,390	224,579	6,769,411	5,247,547	614,866
1.0 m	23,764,356	6,285,455	2,285,380	6,914,757	112,289	1,942,905	5,092,650	307,433
0.5 m	22,120,655	3,479,079	1,434,394	4,606,116	0	1,184,945	4,989,385	307,433

Figure 19 Number of Residents in Affected Areas (2100)



	Alexandria	Beheira	Dakhlia	Dameitta	Ismaalia	Kafr El-Sheikh	Port said	Sharkia
2.0 m	90%	36%	30%	100%	4%	48%	100%	3%
1.5 m	90%	24%	14%	98%	2%	32%	99%	1%
1.0 m	90%	15%	5%	49%	1%	9%	96%	1%
0.5 m	84%	8%	3%	33%	0%	6%	94%	1%

Figure 20 Percentage of Residents in Affected Areas (2100)

Port Said, although contributing 6% of the total residents in affected areas in the 2-meter scenario, is notable because the change in affected areas in all scenarios almost does not affect the number of affected residents. Furthermore, the 5 million affected residents account for nearly 100% of the total population of Port Said, as shown in Figure 20. Given Port Said's critical importance to Egypt's economy and infrastructure (section 4.1), it is poised to become a focal region for SDM in response to SLR. This is particularly significant because Port Said is located on the eastern side of the Delta (Figure 17), which experiences the highest submergence rate in the entire Delta region, at 3.4 mm/year (IPCC, 2021).

Damietta, another vital economic center in Egypt, presents a major concern, especially in the 1.5- and 2.0-meter SLR scenarios, in which nearly 100% of its population resides in affected areas. Damietta too is located on the highly vulnerable eastern side of the Delta (Figure 17). Although decreasing significantly, this percentage remains noteworthy in the 1.0- and 0.5-meter scenarios (approximately 50% and 30% respectively).

Given its significance to the region, Alexandria is another critical focal region for SDM in response to SLR. Not only does it account for a significant portion of the residents in affected areas, but also 90% of its population is projected to live in affected areas across all four scenarios. Finally, considerable percentages of residents in Kafr El-Sheikh, Beheira and Dakahlia could be affected (Figure 20).

5.5 Recap: Egypt SLR Focal Points

The analysis presented in this chapter is grounded in the findings from the hackathon, using a cause-and-effect narrative which simplifies the complex dynamics of both direct and slow-onset impacts of SLR. Results should be considered indicative rather than definitive, given the exploratory nature of the hackathon's approach, and the complex, interconnected, and contextual factors driving SDM. However, this chapter is essential in identifying potential focal regions for SLR-related SDM in Egypt's North Coast and Delta. This step is critical, as it aligns with the theoretical framework to quantify future coping mechanisms and the interconnected dynamics of SDM in response to SLR.

Table 2 Egypt SLR Focal Regions Under Different Scenarios

Governorate	SLR (2100)	Approximate Area Affected	% Affected/ Total Residents Affected	% Residents Affected/ Total Governorate
Alexandria	2.0 m	25%	35%	90%
	1.5 m	25%	44%	90%
	1.0 m	25%	60%	90%
	0.5 m	25%	66%	84%
Port said	2.0 m	100%	6%	100%
	1.5 m	90%	7%	99%
	1.0 m	85%	9%	96%
	0.5 m	70%	11%	94%
Dameitta	2.0 m	100%	12%	100%
	1.5 m	100%	14%	98%
	1.0 m	0%	10%	49%
	0.5 m	0%	8%	33%
Kafr El-Sheikh	2.0 m	50%	13%	48%
	1.5 m	20%	11%	32%
	1.0 m	0%	4%	9%
	0.5 m	0%	3%	6%
Beheria	2.0 m	20%	17%	36%
	1.5 m	15%	15%	24%
	1.0 m	10%	12%	15%
	0.5 m	5%	8%	8%
Dakhlia	2.0 m	50%	15%	30%
	1.5 m	10%	9%	14%
	1.0 m	0%	4%	5%
	0.5 m	0%	3%	3%

Table 2 summarizes the approximate impacts in each governorate due to 0.5, 1.0, 1.5, and 2.0 meters SLR by 2100. Column 1 indicates the approximate percentages of affected areas relative to the total area per governorate. Column 2 indicates the approximate percentages of affected residents relative to the total affected population across the entire study area. Column 3 indicates the approximate percentages of affected residents relative to the total number of residents per governorate.

The analysis reveals that Damietta and Port Said governorates are highly susceptible. Particularly, Port Said is nearly 100% affected under all SLR scenarios and is situated on the eastern side of the delta with the highest submergence rate, indicating that SDM in Port Said could be more rapid than in other affected areas. Damietta's vulnerability is similar to that of Port Said; however, it significantly decreases in the 1.0- and 0.5-meter SLR scenarios, although it remains a substantial concern.

Alexandria is another critical focal region for SDM due to its high population density and the fact that its affected area remains relatively unchanged across all four scenarios, potentially accounting for up to 66% of the affected population in the 0.5-meter SLR scenario.

According to the analysis in this chapter, Kafr El-Sheikh, Beheira and Dakahlia governorates are less susceptible. However, Kafr El-Sheikh and Beheira have already grabbed much attention due to experiencing significant slow-onset impacts related to SLR, such as increased soil salinity and saltwater intrusion as well as reported incidences of SDM and vulnerability disparities- as detailed in Chapter 4. In contrast, Dakahlia holds the largest portion of agricultural land in Egypt's Delta, covering almost 11% of the total agricultural area in the region (Egypt State Information Service, 2022). Additionally, literature highlights that Dakahlia is currently highly vulnerable to pollution (Joshi et al., 2022). This indicates that Kafr El Sheikh, Dakahlia and Beheira, too, should be considered focal regions for SDM studies in Egypt's North Coast and Delta. The following chapter provides further analysis to draw a more accurate picture of SLR-related SDM in Egypt's North Coast and Delta.

6 Exploring Coping Mechanisms in Egypt's North Coast and Delta

6.1 Analyzing Questionnaire Data

6.1.1 *Decoding Questionnaire Answers*

The questionnaire complements the analysis presented in Chapter 5 and provides additional insights into SLR-related SDM in Egypt's North Coast and Delta. The questionnaire mirrored the theoretical framework outlined in Section 3.1. Participants started by selecting a community from a list of those considered vulnerable to SLR, either currently or in the future. By completing the questionnaire, participants provided a comprehensive overview of the communities' situation and responses to SLR and suggested the most effective mitigation measures. For specific information about the questionnaire, refer to Annex B.

Participants came from diverse backgrounds- Annex C provides a list of questionnaire participants. Many had extensive field experience with communities, while others had no field experience. However, most participants were Egyptian, and many belonged to specific communities or had personal interactions with them. Therefore, at the beginning of the questionnaire, participants were prompted to specify whether their answers regarding the current situation of communities would draw from personal familiarity, professional experience, or common knowledge.

To further clarify the basis for the selections of the communities' most likely coping mechanisms, participants were required to specify whether their answers in this regard were grounded in personal or professional experiences, opinions on likely future responses based on their encounters with communities, or common knowledge. This specification aimed to distinguish if their choices were informed by events that they had witnessed firsthand, versed insights, or general perceptions. By providing this context, the responses were more accurately understood, ensuring that the rationale behind each answer was clear and appropriately categorized.

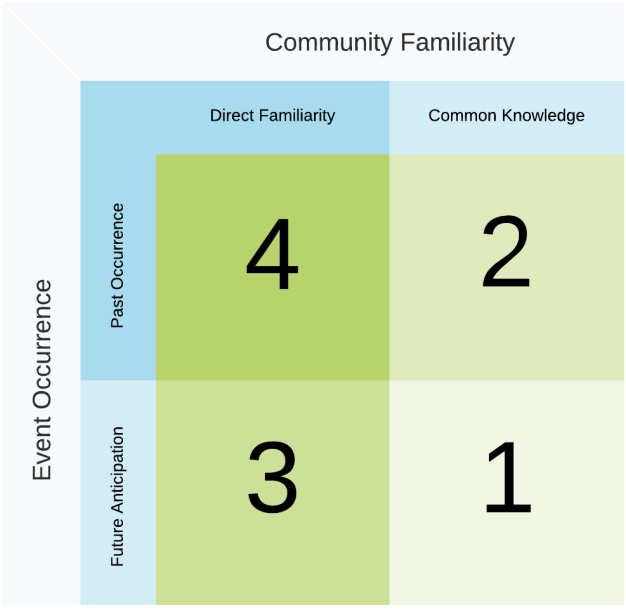


Figure 21 Weighting of Questionnaire Responses

Based on this specification, answers were grouped and weighted according to their accuracy in describing communities' responses to SLR (Figure 21). The highest weight was assigned to responses derived from personal or professional familiarity with the community, where the participant has direct acquaintance with the people and has witnessed specific events (communities' coping mechanisms) firsthand. The second-highest weight was given to responses based on personal or professional Familiarity with the community, where the participant knows the people but the chosen coping mechanisms are based on their opinion or understanding of how the community might respond in the future. The third weight was assigned to answers where participants did not have previous familiarity with the community but selected a coping mechanism based on the knowledge that this specific community had previously used it (indicating that they knew the event had occurred). Finally, the lowest weight was given to answers based on common knowledge where participants had no direct encounters with the community, and the chosen coping mechanism was based on opinion regarding a potential future occurrence.

This method was developed specifically for this report based on insights gathered during the hackathon. The highest weight was given to responses directly informed by participants' familiarity with the communities and events, while the lowest weight was assigned to answers based on common knowledge. The rationale is that the questionnaire and hackathon centered on the assessments and opinions of participants with firsthand experience, as communities often provide the most relevant insights into current practices. However, in more comprehensive assessments—unlike the rapid nature of this report—it would be important to assign some weight to scientific literature, as participants may lack awareness of emerging adaptation strategies documented in academia, especially since they are not experts in the topic under study.

6.1.2 *Validating Questionnaire Results*

To validate the questionnaire, an inverse indirect calculation was used as a supplementary tool for cross-verifying and contextualizing the results. This method evaluates whether the derived estimates reasonably reflect communities' coping mechanisms in response to SLR. While the calculations in this section are approximate and based on indicative insights due to the complex and evolving nature of the phenomenon, they enhance trust in the results by supporting their contribution to a more comprehensive understanding of the interplay between SLR and community coping mechanisms.

First, published statistics on internal and external migration and land affected by salinization and SLR in Egypt's North Coast and Delta were analyzed. Subsequently, these statistics were compared with questionnaire results indicating the percentage of people who have used internal and external migration to cope with deteriorating livelihoods.

Validation 1: External Migration

In 2020, the total number of external emigrants from Egypt was 3.6 million (Statista, 2024b). About 55% of Egyptian livelihoods depend on agriculture (FAO, 2024a). Assuming that farmers emigrate only when their agriculture-dependent livelihoods deteriorate, it is estimated that 1.98 million Egyptians migrated, with agriculture-related livelihood loss being a key contributing factor. Approximately 15% of Egyptian agricultural lands are severely affected by SLR and salinization (FAO, 2024b). Assuming salinization is uniformly distributed across Egypt's agricultural land, it is estimated that 0.297 million Egyptian farmers emigrated, with agricultural livelihood deterioration caused by SLR and salinization being a key contributing factor. The total area of agricultural land in Egypt is about 4 million hectares (CAPMAS, 2022), with around 2.5 million hectares in the north coast and delta regions (FAO, 2020), representing 62.5% of the total agricultural land. Using this percentage, it can be estimated that around 185,625 people emigrated from the north coast and delta regions to destinations outside the country, with

agricultural livelihood deterioration caused by SLR and salinization being a key contributing factor (Figure 22).

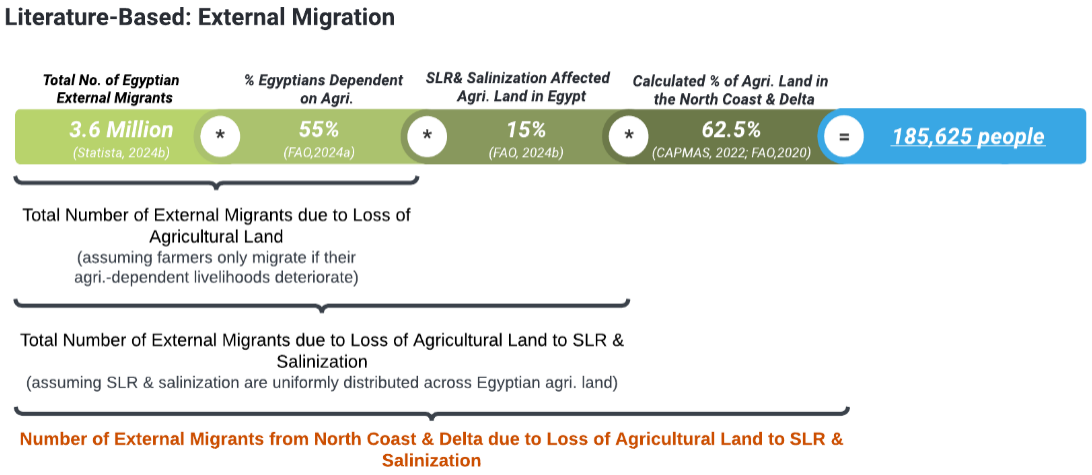


Figure 22 Validation 1.1: External Migration

In comparison, the total area of agricultural land in Egypt is about 4 million hectares (CAPMAS, 2022). With 15% of this land affected by SLR and salinization (FAO, 2024b), approximately 0.6 million hectares suffer from these issues. Since 62.5% of Egypt's agricultural land is located in the north coast and delta regions (CAPMAS, 2022; FAO, 2020), and assuming salinization is uniformly distributed, it is estimated that 0.378 million hectares in these regions are adversely affected due to SLR and salinization. A 2020 remote sensing-based study on agricultural land in Egypt found that losing 100 hectares of agricultural land results in the direct loss of 250 job opportunities (Salem, Tsurusaki, & Divigalpitiya, 2020). Therefore, around 945,000 livelihoods have been adversely affected by SLR and salinization in Egypt's North Coast and Delta regions.

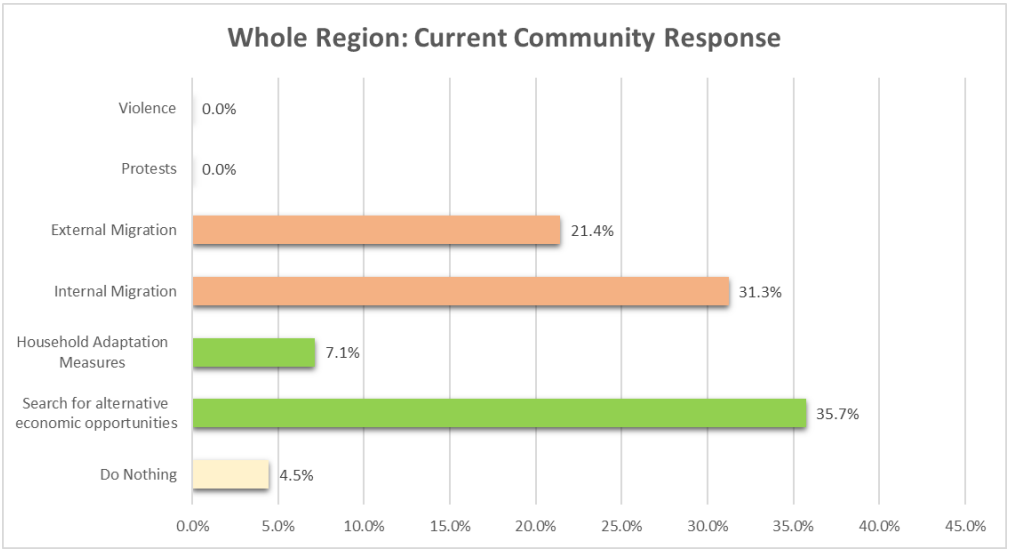


Figure 23 Questionnaire: Communities Coping Mechanisms

Using questionnaire answers that describe past occurrences, derived from direct familiarity with communities and common knowledge (section 6.1.1), the questionnaire illustrated current community responses to SLR and salinization in Egypt's North Coast and Delta (Figure 23). The responses indicate that 21.4% of the affected people have previously used external migration as a coping mechanism. Applying this percentage to the estimated 945,000 livelihoods affected by SLR and salinization suggests

that around 202,230 people have externally migrated, with SLR or salinization-related loss of agriculture-dependent livelihoods being a key contributing factor (Figure 24). This estimate closely aligns with previous statistics and studies, which indicated that 185,625 Egyptians externally migrated from the north coast and delta region, with agricultural land loss from SLR and salinization being a key contributing factor.

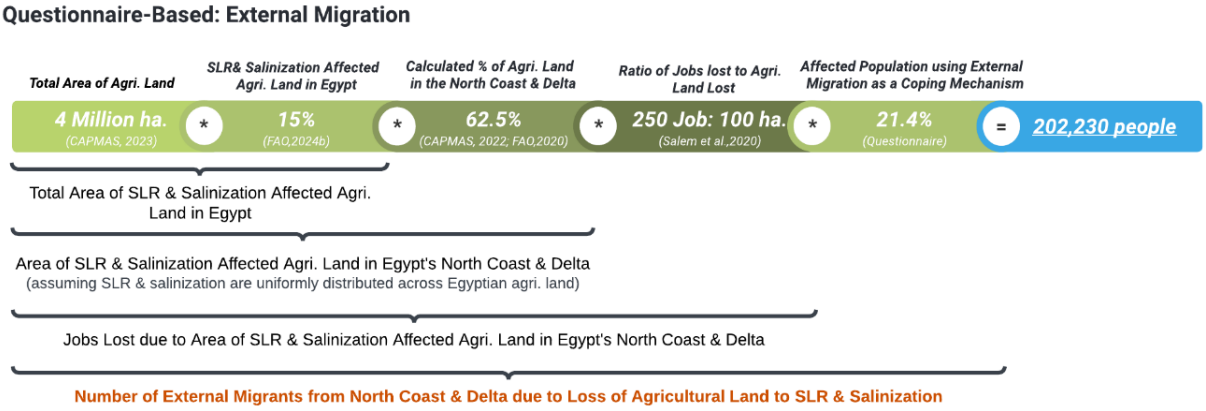


Figure 24 Validation 1.2: External Migration

Validation 2: Internal Migration

Using data from CAPMAS on internal migration and population growth rates, the total number of internal migrants in Egypt is 8 million (CAPMAS, 2023). Assuming 55% of these migrants depended on agriculture, and considering that 15% of agricultural lands are affected by SLR and salinization (FAO, 2024a), with 62.5% of these lands located in the north coast and delta regions (CAPMAS, 2022; FAO, 2020), it is estimated that around 412,500 people migrated from the north coast and delta to destinations inside the country, with deteriorating agriculture-dependent livelihoods from SLR and salinization being a key contributing factor- Figure 25. Questionnaire results indicate that 31.3% of affected people have previously used internal migration as a coping mechanism- Figure 23. Applying this percentage to the affected population suggests that approximately 295,000 people internally migrated from the north coast and delta region, with agricultural land loss due to SLR and salinization being a key contributing factor- Figure 27.

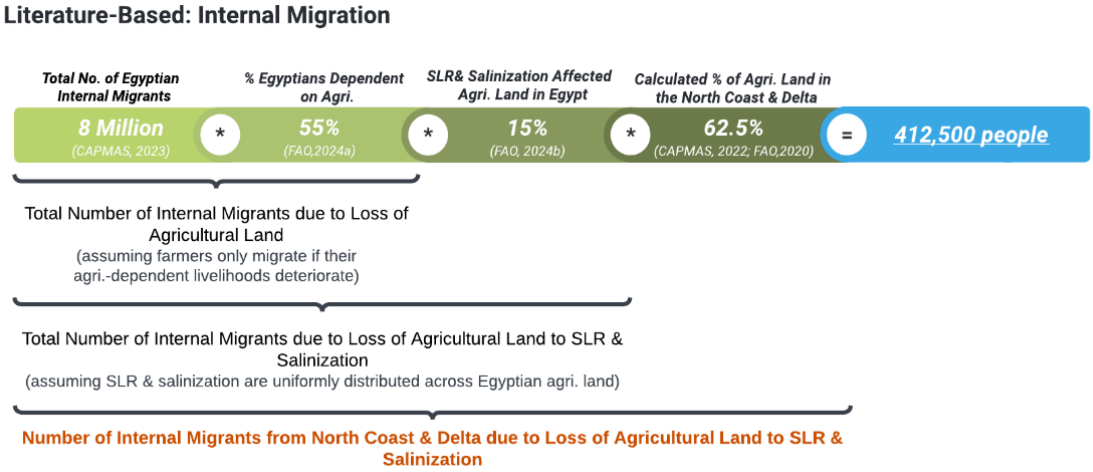


Figure 25 Validation 2.1: Internal Migration

These inverse calculations are inherently based on approximations and indicative insights. Migration due to environmental changes, as discussed in Chapter 2, is a complex, interconnected, and context-specific phenomenon influenced by numerous additional factors, such as fluctuating crop prices and other economic variables. While these calculations cannot account for every influencing element, they align with the rapid nature of this report's assessment. This method serves as a practical approach to validate the questionnaire results, enhancing confidence in the findings despite the complexities involved.

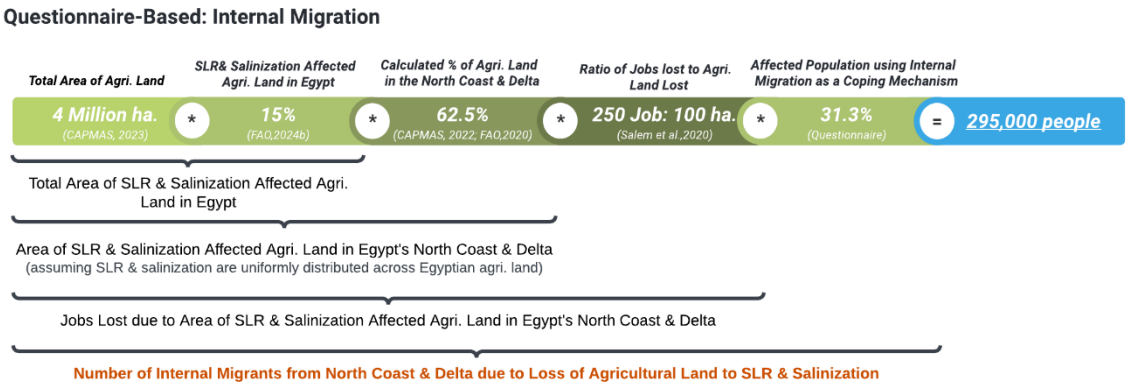


Figure 26 Validation 2.2: Internal Migration.

6.2 Coping Mechanisms Breakdown by Governorate

6.2.1 *Grouping Questionnaire Results*

To predict how the population in Egypt's North Coast and Delta might respond to future SLR, the study uses questionnaire results that quantify the key coping mechanisms employed by affected communities. Thirty-six participants completed the questionnaire- Annex C provides a list of questionnaire participants. Each participant provided responses about two different communities, while some opted to answer for three different communities. As a result, the questionnaire yielded over 72 responses, offering diverse insights into the selected communities. Given the uneven distribution of responses across governorates, the responses are grouped into three categories to ensure robust analysis:

1. Alexandria & Port Said: These key economic centers on the Mediterranean Sea have limited agricultural land, resulting in the least damage in terms of agricultural area and crop loss among the identified SLR focal regions (Team Green, 2024), However, nearly the entire extent of their minimal agricultural land will be impacted. Despite current efforts to expand agriculture in Port Said, both cities remain predominantly urban (CAPMAS, 2023).
2. Damietta & Kafr El-Sheikh: These predominantly rural governorates on the outskirts of Egypt (CAPMAS, 2023), overlooking the Mediterranean Sea, engage in significant agricultural and fishing activities. Press archives indicate their high vulnerability to inundation, salinization, and flooding (section 4.4).
3. Beheira & Dakahlia: Inland, predominantly rural governorates known for their agricultural importance. Both also support inland fishing activities in lakes Manzalah and Idku.

By organizing the responses in this manner, three sets of percentages are calculated to provide a clearer understanding of future coping mechanisms in response to SLR in Egypt's North Coast and Delta.

Figure 27 summarizes percentages of future coping mechanisms for each governorate group. Evidently, "Searching for Alternative Economic Opportunities" within the same location has the highest percentages in all three groups. This is followed by "Internal Migration" and "External Migration" which reflect both the intentions to migrate and the actual implementation of migration. Notably, the decision to migrate does not always translate into action due to various inherent obstacles- as discussed in Chapter 2. These differences in percentages highlight the varying levels of community vulnerability as well as community nature across vulnerable governorates.

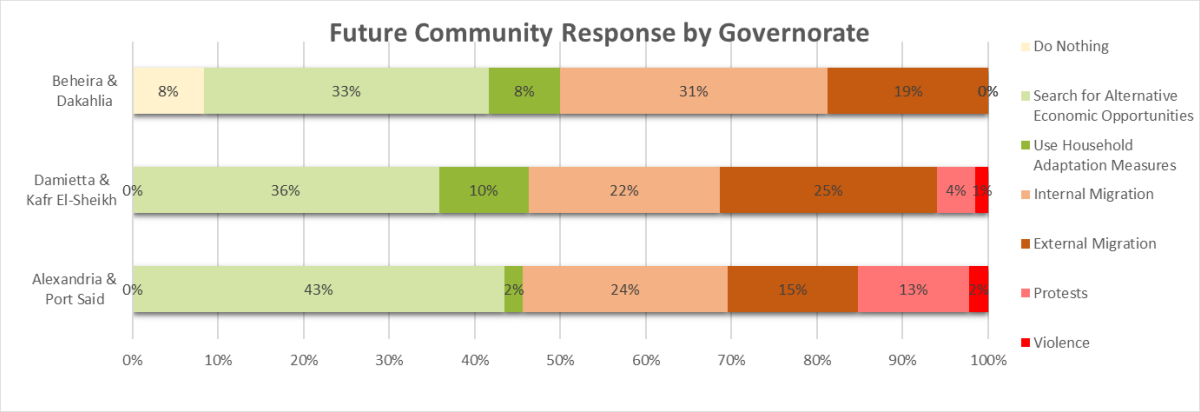


Figure 27 Percentage of Coping Mechanism by Governorate

6.2.2 *Results by Governorate*

"Using Household Adaptation Measures" is highest in Damietta and Kafr El-Sheikh, both of which are currently highly suspectable to SLR-related inundation and flooding as indicated by previous analysis (section 4.3). Long-term exposure to flooding has normalized household adaptation measures in these areas, with some residents implementing them annually. The second highest usage of household adaptation measures is in Beheira and Dakahlia. These governorates are starting to experience slow-onset impacts of SLR, such as salinity intrusion into water sources (section 4.4).

In contrast, Alexandria and Port Said show only 2% for "Using Household Adaptation Measures". As major urbanized economic centres, their infrastructure has traditionally been more developed. Only in recent years have they frequently faced extreme flooding and inundation, meaning residents are not yet familiar with SLR impacts, and thus, household adaptation measures are less common.

The shock of increased flooding and inundation incidents in Alexandria and Port Said also explains the highest percentages of potential "Protests" and "Violence" in these governorates. These two categories account for 15% of Alexandria and Port Said responses. Similarly, Damietta and Kafr El-Sheikh also show potential for "Protests" and "Violence" (5%). This is related to the current increasing deterioration of livelihoods, particularly for fishermen and certain crop producers- as indicated in sections 4.3 and 4.4.

Beheira and Dakahlia show 0% for "Protests" and "Violence," likely because the impact on livelihoods is less severe. In addition, the residents, predominantly farmers, tend to be more patient (El-Koumy, 2024), explaining the visible percentage of inaction- "Doing Nothing"- in these governorates.

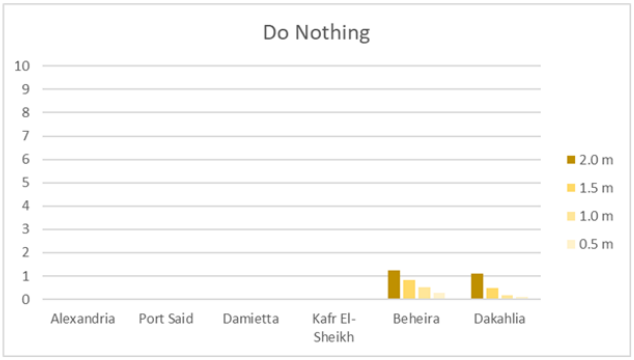
Correspondingly, farmers typically reside with their families year-round, unlike fishermen who may be away at sea for extended periods. This likely explains why Beheira and Dakahlia have the highest percentages of "Internal Migration." Internal migration allows farmers to return to their homes at least once a week, maintaining close family ties.

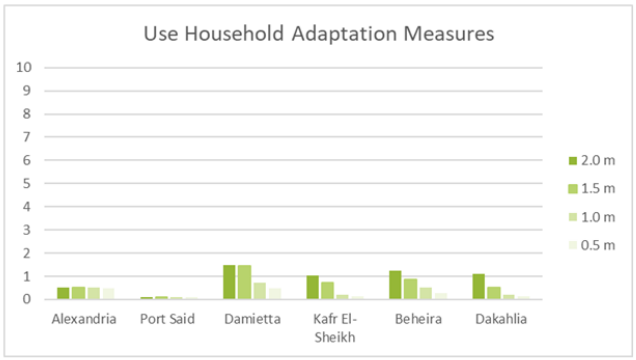
"External Migration" is highest in Damietta and Kafr El-Sheikh. With rural governorates on the outskirts of Egypt being hotspots for illegal emigration to Europe, as documented in multiple media reports (Ahram Online, 2017; Changpertitum, 2015; Emam, 2018), external migration, both legal and illegal, has become a normalized response to deteriorated livelihoods in these governorates.

The percentages for each coping mechanism by governorate are utilized to project the potential numbers (in millions) of individuals employing each strategy by the year 2100, under the scenarios of 2.0, 1.5, 1.0, and 0.5 meters of SLR. The summarized figures are presented in Table 3, Figure 28, Figure 29 and Figure 30.

Table 3 Distribution of Affected Population per Coping Mechanism

SLR (2100)	Total Number by 2100 (Million)						
	Do Nothing	**Search for Alternative Economic Opportunities**	**Use Household Adaptation Measures**	**Internal Migration**	**External Migration**	**Protests**	**Violence**
0.5 m	0.41	15.50	1.60	9.31	6.52	3.80	0.68
1.0 m	0.71	18.58	2.27	11.56	8.25	4.16	0.76
1.5 m	1.35	25.39	4.13	16.60	12.68	4.71	0.94
2.0 m	2.36	30.74	5.52	21.22	15.87	4.87	0.99





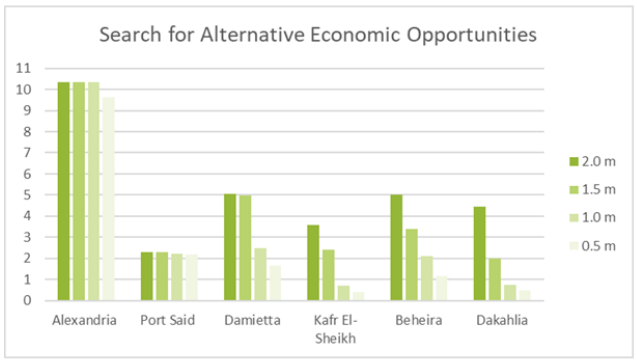
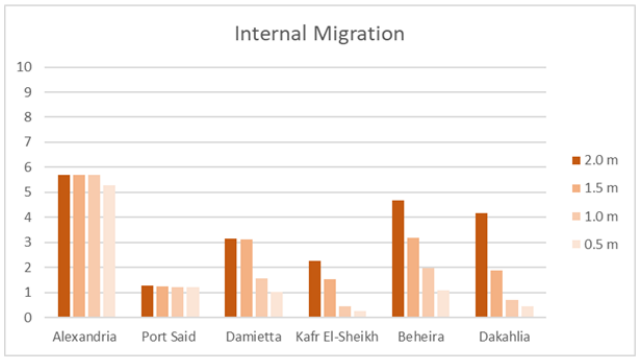


Figure 28 Coping Mechanisms per Governorate in Numbers 1.1



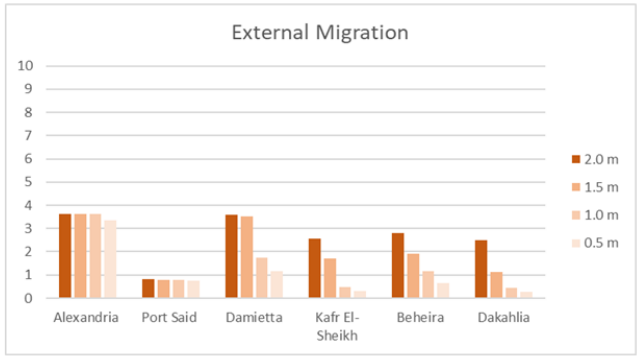
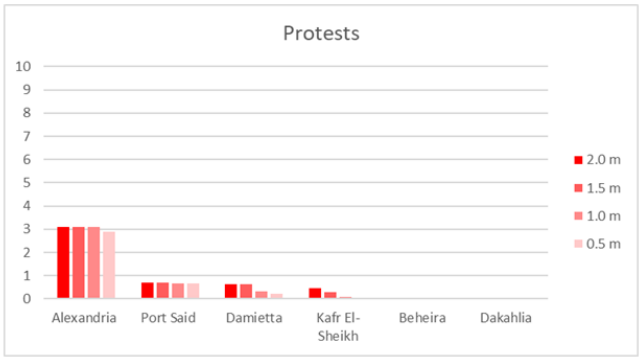


Figure 29 Coping Mechanisms per Governorate in Numbers 1.2



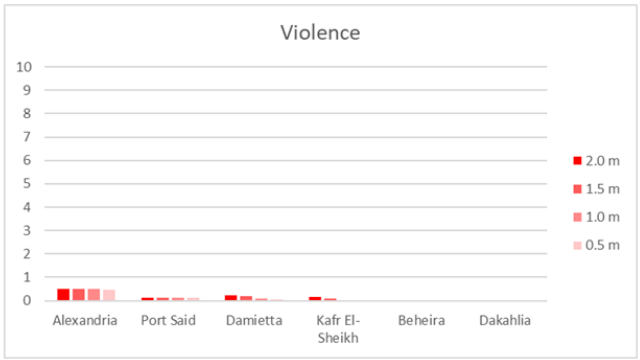


Figure 30 Coping Mechanisms per Governorate in Numbers 1.3

6.3 Coping Mechanisms Sensitivity to SLR Scenario

Subsequently, simple sensitivity analyses are conducted to examine how changes in SLR scenarios impact the number of people adopting different coping mechanisms. The sensitivity analyses are conducted by calculating the percentage increase in the number of people adopting each coping mechanism as SLR scenarios intensify, specifically comparing the 0.5 m SLR scenario to the 2.0 m SLR scenario. Calculating the percentage change for each coping mechanism allows for assessing their relative sensitivity and adaptability to intensifying SLR.

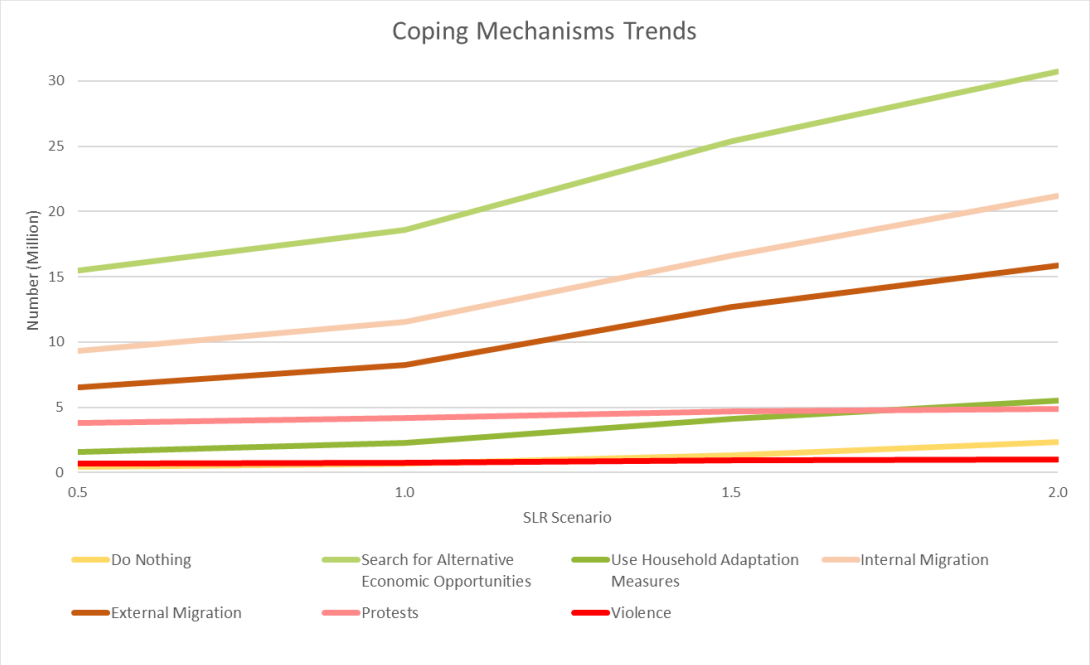


Figure 31 Coping Mechanisms Trends

As the 2100-SLR scenario increases from 0.5m to 2.0m, the number of people opting to "Using Household Adaptation Measures" increases significantly, from approximately 1.6 million to 5.5 million, a 245% increase.

Considerable attention should be paid to internal and external migration. Internal Migration (of the affected population) increases from 9.3 million to about 21 million, an increase of approximately 130%. External Migration shows a notable increase from 6.5 million to around 15.8 million, indicating an approximate 145% increase. "Searching for Alternative Economic Opportunities", the most common response, increases from about 15.5 million to over 30 million, an increase of roughly 100%.

"Protests" and "Violence" exhibit less pronounced changes. "Violence" remains relatively stable at around a million, showing minimal change. "Protests" swell slightly from about 4 million to 5 million, an approximate 30% increase.

Table 4 Sensitivity Analysis (Percentages reflect the increase in affected population from the 0.5 m to 2.0 m SLR scenario)

Coping Mechanism	% Increase 0.5 m to 2.0-m SLR
Do Nothing	476 %
Use Household Adaptation Measures	244 %
External Migration	143 %
Internal Migration	127 %
Search for Alternative Economic Opportunities	98 %
Violence	46 %
Protests	28 %

In summary (Table 4), significant increases are observed in “Using Household Adaptation Measures”, “External Migration”, “Internal Migration” and “Searching for Alternative Economic Opportunities” as SLR scenarios intensify. “Protests” and “Violence” are less affected by changes in SLR scenarios. However, considerable attention should be paid since they prompt significant security implications. The analysis underscores the need for a balanced approach in addressing these coping mechanisms, considering both their inherent importance and sensitivity to intensifying SLR.

6.4 Shaping Coping Mechanisms

6.4.1 *Key Influencing Factors*

The questionnaire was used to identify key factors influencing individuals' choices of coping mechanisms in response to SLR in Egypt's North Coast and Delta. The analysis reveals that financial needs are a primary factor affecting the choice of all coping strategies. These needs can be addressed through personal financial resources or governmental subsidies and support programs. Combined, "Financial Capacity" and "Governmental Subsidies or Support" account for over 50% of the influence on the choice of coping mechanisms, with their impact rising to 70% in cases of opting for "Violence" (Figure 32).

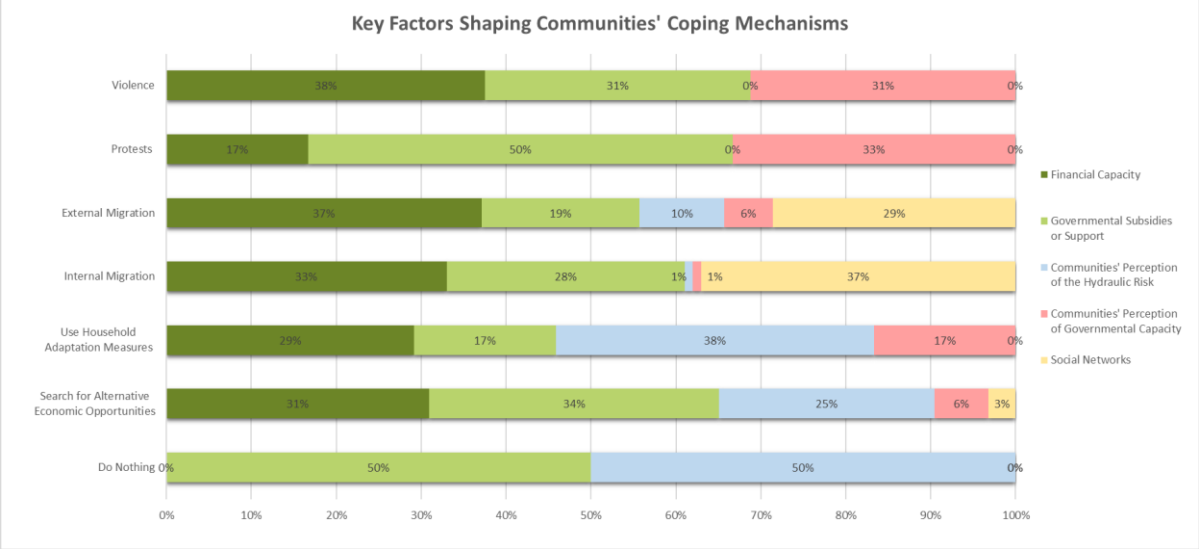


Figure 32 Key Factors Percentage Per Coping Mechanisms

Another significant factor is "Communities' Perceptions of Government Capacity", often referred to as ‘Trust’ in scientific literature. The data show that perceptions of government effectiveness influence the choice of “Protests” or “Violence” by more than 30%.

Additionally, "Communities' Perception of the Hydraulic Risk" is an important consideration. Many communities lack awareness about the risks associated with SLR, which often leads to a reliance on "Doing Nothing" or influences "Using Household Adaptation Measures" This indicates that increased awareness about the risk is crucial for enabling communities to take proactive measures.

"Social Networks" play a critical role in decisions related to "Internal Migration" or "External Migration." Migration typically depends on social networks to help identify destinations (Al-Ragehy, 2024). This is discussed in more detail in Chapter 2.

6.4.2 *Population Characteristics*

Category/ Type

The questionnaire results were also used to identify the characteristics of communities that use specific coping mechanisms in response to SLR. First, the projected responses of various community types are specified by indicating the percentage of each group likely to employ certain coping mechanisms. Female Household Heads on Subsidies show a significant inclination toward "Doing Nothing" (36%), with some considering the "Use of Household Adaptation Measures" (8%). Bedouins/Nomads are split between "Doing Nothing" (27%), "Internal Migration" (10%), and resorting to "Violence" (50%). Farmers are the most likely to engage in "Protests" (67%), with percentages considering "Internal Migration" (46%), External migration (43%), and a portion turning to "Using Household Adaptation Measures" (25%).

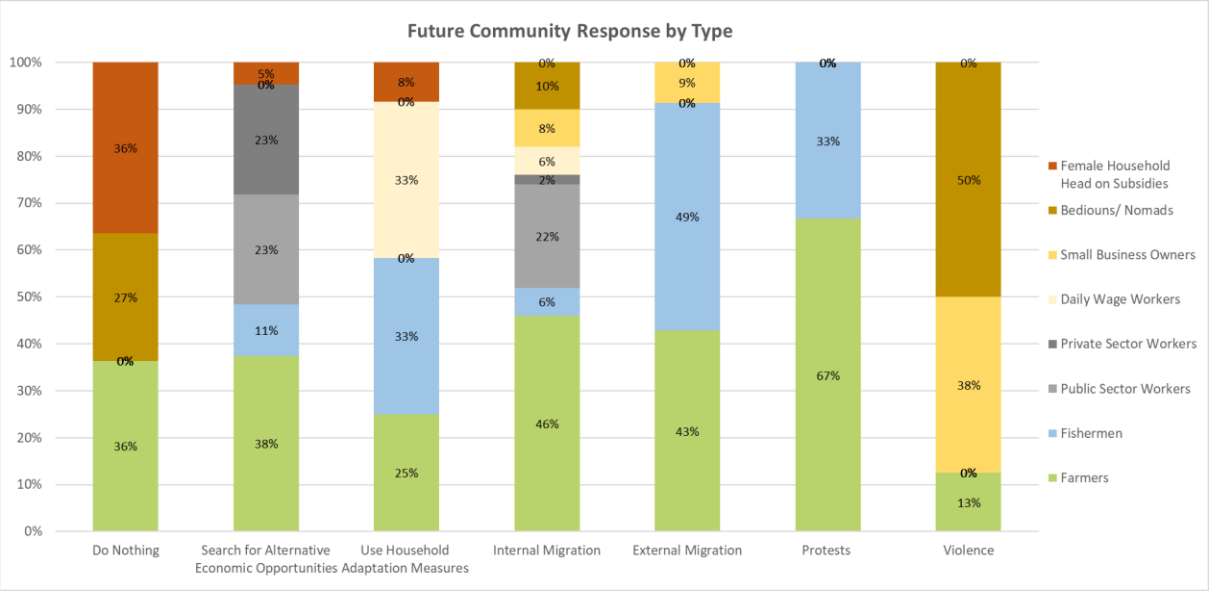


Figure 33 Community Type Per Coping Mechanism

Private Sector Workers have varied responses, with 23% considering "Searching for Alternative Economic Opportunities", and 22% leaning towards "Internal Migration". Fishermen lean towards "External Migration" (49%). The rest are predominantly divided between "Protests" (33%) and "Using Household Adaptation Measures" (33%), with smaller percentages considering other options. Private Sector Workers are mainly inclined toward "Searching for Alternative Economic Opportunities" (23%).

Finally, Small Business Owners have the smallest representation, potentially accounting for 38% of the affected population turning to "Violence". Overall, Farmers emerge as a prominent community when considering SLR- Figure 33. This is logical since farmers make up the majority (55%) of the population in Egypt's North Coast and Delta (FAO, 2024a).

Age

Following, the age groups of people using specific coping mechanisms were examined, as shown in Figure 34. Notably, older citizens (over 50) show a predominant preference (80%) for "Using Household Adaptation Measures". The middle-aged group (31-50) appears more inclined toward "Internal Migration" (51%) and "Searching for Alternative Economic Opportunities" (70%). In contrast, youth (18-30) exhibit a strong propensity toward "External Migration" (71%) and participation in "Protests" (67%). These variations suggest that SLR could lead to significant internal and external migration, particularly among younger populations, potentially straining urban areas and foreign regions. Furthermore, the high likelihood of protests among youth and middle-aged individuals underscores the potential for social unrest.

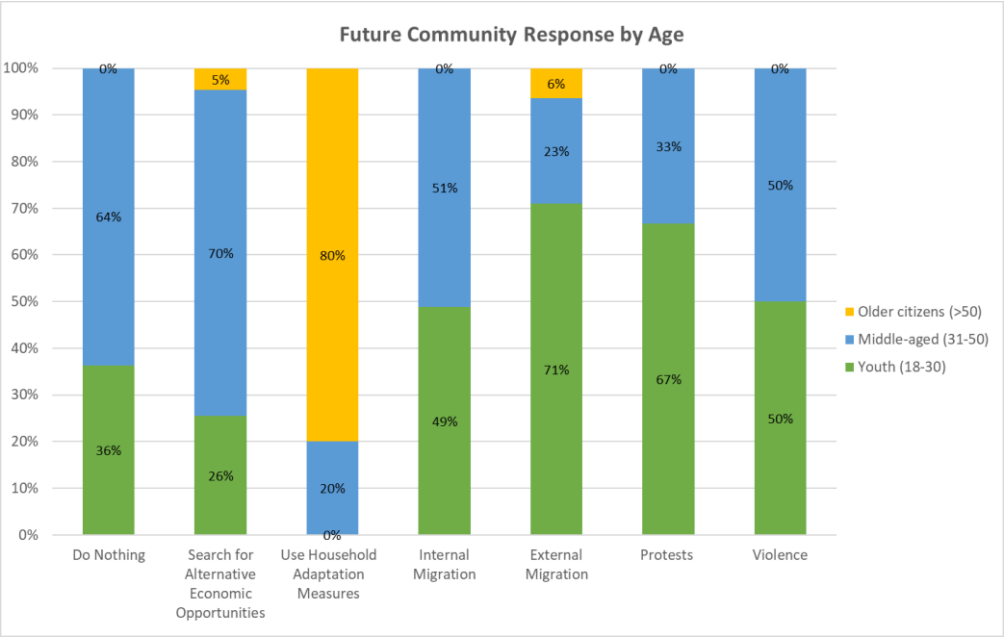


Figure 34 Age Percentage Per Coping Mechanism

Education

The level of education was also explored- Figure 35. Numbers reveal that illiterate individuals overwhelmingly tend to "Do Nothing" (64%), whereas those with higher education, particularly university degrees and above, are more proactive in "Searching for Alternative Economic Opportunities" (40%). Among the educated groups, secondary and preparatory education holders show significant involvement in "Internal Migration" (32%) and "Using Household Adaptation Measures" (25%), respectively. Notably, those who can only read and write are significantly represented in the "Protest" response (67%), while the illiterate are overwhelmingly represented in "Violence". This data highlights that education level strongly influences the choice of coping mechanisms, with more educated individuals seeking alternative opportunities and adaptation measures, while the less educated are more likely to engage in protests or remain inactive.

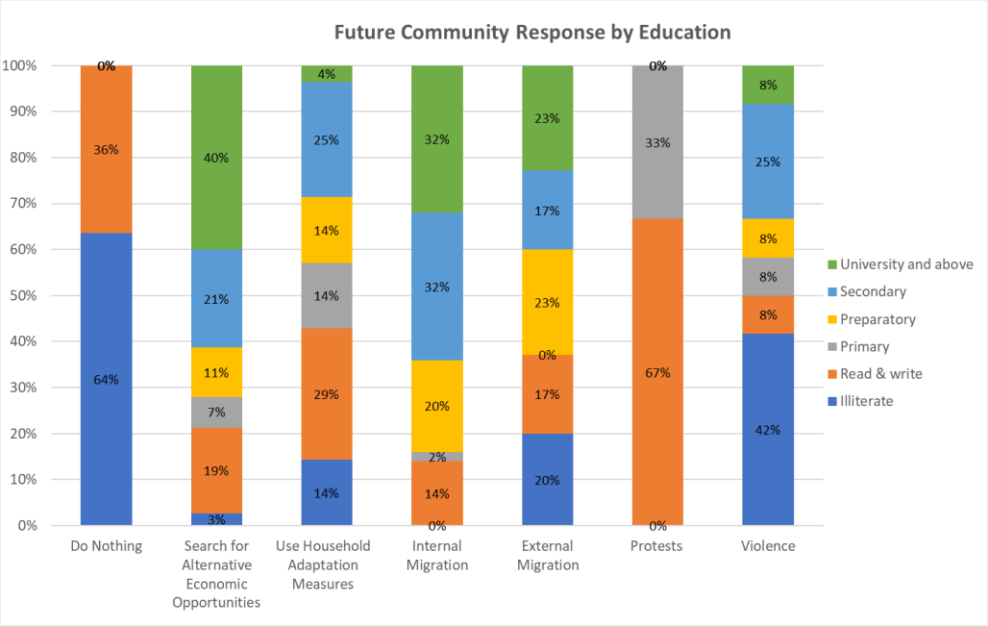


Figure 35 Education Level Percentage Per Coping Mechanism

Gender

Finally, gender per coping mechanism was explored- Figure 36. The data reveals significant gender disparities in coping mechanisms. A majority of females (73%) are inclined to "Do Nothing," while males are more proactive, with 41% searching for alternative economic opportunities and 52% considering internal migration. Both genders participate equally in “Using Household Adaptation Measures” (92%), whereas external migration is almost entirely a male response (100%). “Protests” (100%) and “Violence” (88%) are overwhelmingly undertaken by males. These findings indicate that men are more likely to seek proactive and migration-based solutions, while women are more inclined to adapt within their households or remain inactive. These age-specific tendencies, educational disparities, and gender-specific tendencies must be taken into account by policymakers when crafting strategies to address the impacts of SLR.

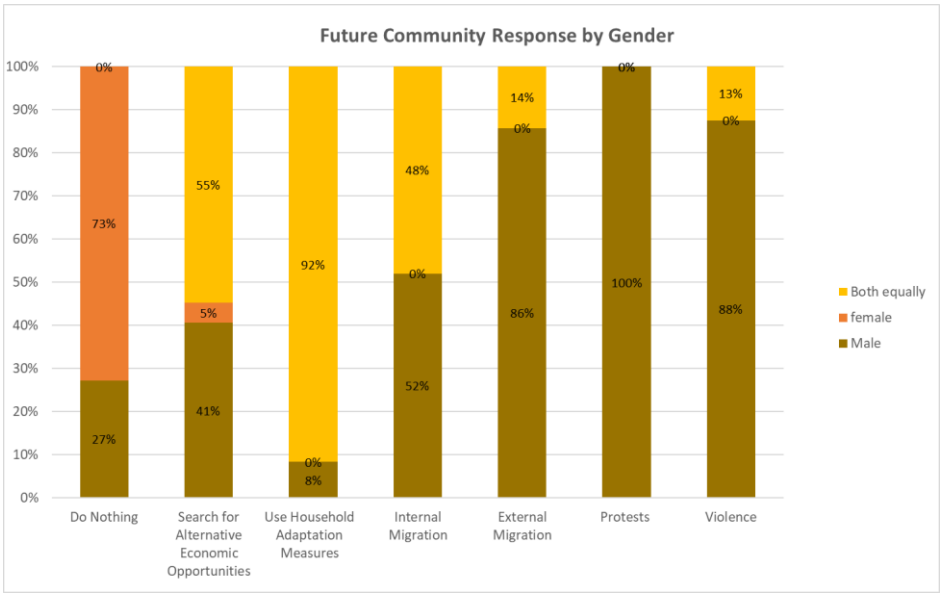


Figure 36 Gender Percentage Per Coping Mechanism

6.5 Recap: Coping Mechanisms, Key Influencing Factors and Community Characteristics

The following breakdown outlines various coping mechanisms across Egypt's SLR Focal Regions, highlighting the demographics and key factors influencing these responses:

1. Violence: Concentrated in Alexandria and Port Said, with some incidents in Damietta and Kafr El-Sheikh. Violence is predominantly adopted by Bedouins (50%) and Small Business Owners (38%). This coping mechanism is primarily chosen by younger or middle-aged men (88%), mostly those with an intermediate or lower education level. The key motivations include financial concerns (70%) and distrust in government (30%).
2. Protests: Similar to violence, protests are most prevalent in Alexandria and Port Said, with some incidents in Damietta and Kafr El-Sheikh. Farmers make up 67% of participants and fishermen 33%. This response is exclusively male and largely driven by younger and middle-aged groups, with intermediate or below intermediate education, similarly motivated by financial issues and government distrust.
3. External Migration: This strategy is notably observed among men (86%), mostly in Damietta and Kafr El-Sheikh. The younger generations (71%) of fishermen (49%) and farmers (43%) are the main groups migrating. Education level is mostly intermediate or below, with motivations spanning financial concerns (56%), knowledge of SLR risk (10%), and low trust in government (6%). Social networks play a role in this decision for 29% of individuals.
4. Internal Migration: This occurs most prominently in Beheira and Dakahlia, the remaining governorates have closely similar percentages. Internal migration engages a diverse group, including farmers (46%) and public sector workers (22%). Men and women adopt this coping mechanism almost equally. Youth (49%) and middle-aged (51%) mostly with above intermediate or higher education dominate this group. The migration decision is influenced by financial reasons (61%) and minimally by knowledge of SLR risk and government trust. Social networks play a significant role in this decision for 37% of individuals.
5. Using of Household Adaptation Measures: Mostly in Damietta, Kafr El-Sheikh, Beheira, and Dakahlia, this approach is utilized by fishermen (33%), daily wage workers (33%), and farmers (25%). Both men and women employ it. The older population, predominantly with intermediate or lower education, adopts these measures, influenced by financial capacity and knowledge of SLR risk.
6. Searching for Alternative Economic Opportunities: This is significant in Alexandria and Port Said; however, all governorates are in close proportionality. Farmers (38%), along with public and private sector workers (23%), seek alternative economic solutions, motivated by financial needs, knowledge of SLR risk, and to a lesser extent, government trust. Mostly middle-aged (both men and women) with above intermediate or higher education dominate this group.
7. Doing Nothing: This passive reaction is potentially most evident in Beheira and Dakahlia, 36% of the respondents are female household heads and farmers. This inaction is largely among middle-aged women with lower or intermediate education, who are influenced equally by financial reasons and knowledge of SLR risk.

This detailed breakdown, summarized in Table 5, provides valuable insights into how communities might respond to SLR by 2100. It highlights potential coping mechanisms based on questionnaire responses reflecting current strategies for addressing livelihood losses, as well as participants' interactions with these communities. The findings align with the theoretical framework presented in Section 3.1, demonstrating its practical relevance. Participants acknowledged that SLR-induced economic damage will disrupt livelihoods, prompting varied coping mechanisms influenced by financial pressures, demographic factors, and levels of trust in the government. These aspects align with the societal and individual adaptive capacities outlined in the framework.

To offer rough estimations of communities adopting specific coping mechanisms in response to SLR, this chapter built on Chapter 5's identification of SLR focal regions and affected populations in Egypt's North Coast and Delta. These calculations rely on insights from the hackathon's rapid assessment. As such, the results are indicative rather than precise, given the exploratory nature of the approach and the complexity of SDM dynamics discussed in Chapter 2.

The primary aim is not to deliver exact figures for design or modelling but to provide initial, quantifiable insights into SDM-related responses to SLR, such as which coping mechanisms are employed, by whom, and under what conditions. The findings presented in this chapter offer a groundbreaking perspective by exploring connections in a largely uncharted and insufficiently researched area (Hauer et al., 2020). This analysis acknowledges the inherent uncertainties and limitations of studying the complex, interconnected, and context-specific phenomena of SLR-induced SDM. Potential SLR impacts on SDM in Egypt remain a significantly underexplored area, and this chapter represents one of the first attempts to address this gap.

While uncertainties remain, these results highlight the urgent need for more in-depth, modelling-based studies tailored to each SLR focal region. Such research would refine predictions by addressing the slow-onset and interconnected nature of SLR and its impacts. These findings serve as a foundational step to guide policymakers in shaping early strategies to address SLR-related SDM impacts and emphasize the need for further, detailed research.

Table 5 Summary of Coping Mechanisms

Coping Mechanism	Dominant in (Governorate)	Community	Gender	Education	Age	Key Factors	Social Networks	Numbers in Millions (0.5-2.0 m SLR by 2100)
Violence	▪ Alexandria & Port Said highest ▪ (Some in Damietta & Kafr El-Sheikh)	▪ 50% Bedouins ▪ 38% Small Business Owners	88% men	▪ 66% Intermediate or Below ▪ (42% illiterate)	▪ 50% Youth, ▪ 50% Middle-Aged	▪ 70% Money ▪ 30% Trust in Government	-	▪ Alexandria: 0.48 - 0.52 M ▪ Port Said: 0.11 - 0.12 M ▪ Damietta: 0.07 - 0.21 M ▪ Kafr El-Sheikh: 0.02 - 0.15 M
Protests	▪ Alexandria & Port Said highest ▪ (Some in Damietta & Kafr El-Sheikh)	▪ 67% Farmers ▪ 33% Fishermen	100% men	▪ 100% Intermediate or Below ▪ (67% read & write)	▪ 67% Youth, ▪ 33% Middle-Aged	▪ 70% Money ▪ 30% Trust in Government	-	▪ Alexandria: 2.89 - 3.10 M ▪ Port Said: 0.65 - 0.69 M ▪ Kafr El-Sheikh: 0.5 - 0.45 M ▪ Damietta: 0.21 - 0.63 M
External Migration	▪ Damietta & Kafr El-Sheikh ▪ (Rest is almost equal)	▪ 49% Fishermen ▪ 43% Farmers	86% men	▪ 60% Intermediate or Below ▪ (almost equal in all)	▪ 71% Youth, ▪ 23% Middle-Aged	▪ 56% Money ▪ 10% Knowledge of SLR Risk ▪ 6% Trust in Government	29% dependent on Social Networks	▪ Alexandria: 3.37 - 3.62 M ▪ Damietta: 1.17 - 3.58 M ▪ Port Said: 0.76 - 0.81 M ▪ Beheira: 0.65 - 2.81 M ▪ Kafr El-Sheikh: 0.30 - 2.55 M ▪ Dakahlia: 0.27 - 2.50 M
Internal Migration	▪ Beheira & Dakahlia highest ▪ (All Almost Equal)	▪ 46% Farmers ▪ 22% Public Sector Workers ▪ 10% Bedouins	52% men	▪ 32% Above Intermediate, ▪ 32% University & Above	▪ 49% Youth, ▪ 51% Middle-Aged	▪ 61% Money ▪ 1% Knowledge of SLR Risk ▪ 1% Trust in Government	37% dependent on Social Networks	▪ Alexandria: 5.59 - 5.68 M ▪ Port Said: 1.19 - 1.27 M ▪ Beheira: 1.09 - 4.69 M ▪ Damietta: 1.08 - 3.16 M ▪ Dakahlia: 0.45 - 4.17 M ▪ Kafr El-Sheikh: 0.27 - 2.25 M

Coping Mechanism	Dominant in (Governorate)	Community	Gender	Education	Age	Key Factors	Social Networks	Numbers in Millions (0.5-2.0 m SLR by 2100)
Use Household Adaptation Measures	▪ Damietta ▪ Kafr El-Sheikh ▪ Beheira ▪ Dakahlia	▪ 33% Farmers ▪ 33% Daily Wage Workers ▪ 25% Farmers	92% both	▪ 71% Intermediate or Below ▪ (29% Read& Write)	▪ 80% Older Citizens	▪ 46% Money ▪ 38% Knowledge of SLR Risk ▪ 17% Trust in Government	-	▪ Damietta: 0.48 - 1.48 M ▪ Alexandria: 0.48 - 0.52 M ▪ Beheira: 0.29 - 1.25 M ▪ Dakahlia: 0.12 - 1.11 M ▪ Kafr El-Sheikh: 0.12 - 1.05 M ▪ Port Said: 0.11- 0.12 M
Search for Alternative Economic Opportunities	▪ Alexandria & Port Said highest ▪ (All Almost Equal)	▪ 38% Farmers ▪ 23% Public Sector Workers ▪ 23% Private Sector Workers	41% men	▪ 40% University & Above, ▪ 21 % Above Intermediate	▪ 70% Middle-Aged, ▪ 26% Youth	▪ 65% Money ▪ 25% Knowledge of SLR Risk ▪ 6% Trust in Government	3% dependent on Social Networks	▪ Alexandria: 9.62 - 10.33 M ▪ Port Said: 2.17 - 2.30 M ▪ Damietta: 1.65 - 5.06 M ▪ Beheira: 1.16 - 5.00 M ▪ Dakahlia: 0.48 - 4.44 M ▪ Kafr El-Sheikh: 0.42 - 3.60 M
Do Nothing	▪ Beheira ▪ Dakahlia	▪ 36% Female Household Head Women ▪ 36% Farmers	73% Women	▪ 100% Intermediate or below ▪ (64% Illiterate, 36% Read& Write)	▪ 64% Middle-Aged, ▪ 36% Youth	▪ 50% Money ▪ 50% Knowledge of SLR Risk	-	▪ Beheira: 0.29 - 1.25 M ▪ Dakahlia: 0.12 - 1.11 M

7 Reflections, Mitigation Pathways and Concluding Insights

7.1 Reflections

SLR in Egypt's North Coast and Delta has significant socio-economic impacts. This includes regions directly affected seasonally or perennially by 2100, areas with deteriorated lands or services, and extending to the rest of Egypt and neighboring countries. The broader impact is due to two main reasons:

First, asset losses and economic damages (as discussed in Section 5.3) encompass significant reductions in agricultural land and vital crops, massive infrastructure damage in the north coast and delta, and losses in tourism and economic development crucial to Egypt's economy. These losses will, in turn, have widespread economic, health, and social repercussions.

Second, the coping mechanisms adopted in response to SLR will affect regions not necessarily directly impacted by rising sea levels. For instance, seeking alternative economic opportunities could lead to higher unemployment and weaker labor rights. Internal migration would likely increase urbanization rates and strain already overburdened infrastructure, while external migration, especially if unplanned or illegal, could stress neighboring countries.

Moreover, the slow-onset impacts of SLR, though harder to predict and less visible, are already affecting livelihoods and are becoming more evident in certain areas, as highlighted in Section 4.4. This aligns with the theoretical framework (section 3.1), which explains how individuals facing insecurities related to basic needs like water, food, healthcare, income, or education often resort to coping mechanisms such as migration, seeking alternatives, or protesting. These responses can further exacerbate existing community issues, such as social inequity, gender inequality, and family breakdown, potentially leading to social disruption well before the physical impacts of SLR are noticeable. For instance, in countries like Bangladesh, Indonesia, and Vietnam, income declines have pushed farmers to switch from agriculture to aquaculture while many farmers and fishermen chose to migrate, as discussed in Section 2.1. Similar patterns are emerging in Egypt's Kafr El-Sheikh, Damietta, Alexandria, and Port Said, as noted in Section 4.5. In Vietnam, vulnerability disparities were stark, with young migrants facing harsh working conditions and minimal pay, while the elderly and women left behind struggled with increased workloads. These challenges are also becoming more apparent in Egypt, leading to increased psychological and physical health burdens as detailed in Section 4.6.

These slow-onset impacts are still under-researched but are crucial in understanding the full scope of SDM due to SLR in Egypt. Innovative approaches are urgently needed to study these slow-onset impacts, which are accumulating and could significantly alter the directly projected outcomes of SLR by influencing population growth, migration trends, and overall regional dynamics.

7.2 Mitigation Pathways

As a final step questionnaire participants were asked to indicate the most appropriate mitigation pathways. Table 6 presents an expert-opinion-based comparative analysis of mitigation measures across three governorate groups: Alexandria & Port Said, Damietta & Kafr El-Sheikh, and Beheira & Dakahlia. The mitigation strategies are divided into two broad categories: Technical and/or National Measures and Community-Oriented Measures.

Table 6 Most Relevant Mitigation Measures by Governorate. (The percentages and green bars represent the proportion of questionnaire participants who selected each mitigation measure as the most suitable for addressing the situation, either currently or in the future)

Mitigation Measure		Alexandria & Port Said	Damietta & Kafr El-Sheikh	Beheria & Dakahlia
Technical and/or National Measures	Flood Protection (coastal areas)	13%	10%	7%
	Wet Infrastructure (Inland)	11%	9%	12%
	Hard Infrastructure	2%	2%	5%
	Beach Renourishment	3%	6%	0%
	Governmental subsidies for resilient housing	5%	2%	5%
	International Investment	8%	12%	16%
	Foreign Aid	1%	3%	2%
	Enhanced Political system and Institutional Capacity	7%	4%	2%
Community-Orinted Measures	Relocating communities	0%	5%	2%
	Stakeholder Engagement	13%	5%	6%
	Social Equity	14%	12%	5%
	Raising Awareness	11%	10%	7%
	Special Education	3%	9%	12%
	Facilitating NGOs' work	8%	6%	12%
	None	0%	0%	2%
	Other	1%	5%	6%

In the category of Technical and/or National Measures, Alexandria & Port Said, as well as Damietta & Kafr El-Sheikh, show a relatively balanced distribution across various approaches such as "Flood Protection", "Wet Infrastructure", and "International Investment". However, participants indicate a stronger emphasis on "International Investment" in Beheira & Dakahlia, with 16% of the efforts focused here, suggesting a reliance on external funding for mitigation. "Enhanced Political System and Institutional Capacity" and "Government Subsidies for Resilient Housing", while less indicated by experts, are considered measures in all governorates.

Community-oriented Measures show significant engagement in social equity and stakeholder engagement, especially in Alexandria & Port Said, where 14% and 13% of the measures, respectively. Experts also prioritize social equity in Beheira & Dakahlia, indicating a broad recognition of the need for inclusive, community-focused interventions in these governorates. However, what stands out is the incorporation of "Special Education" initiatives, particularly in Beheira & Dakahlia, where experts indicated that 12% of efforts should equip communities with the skills needed to diversify their livelihoods beyond traditional farming and fishing. This reflects a forward-thinking approach to building long-term resilience by promoting alternative economic activities.

Additionally, experts emphasize "Facilitating NGOs' Work" to direct efforts toward enabling NGOs to work more effectively with local communities. This support for NGOs is crucial, as it allows these organizations to play a more active role in helping communities adapt to the challenges of SLR through targeted interventions and capacity-building initiatives. Relocating communities, while considered,

appears less prioritized by experts across all governorates, reflecting the complexity and resistance associated with such measures in combination with a lower perceived necessity.

Overall, the table underscores expert opinions on mitigation strategies tailored to the specific needs and contexts of each governorate group. An almost even distribution between technical measures and community-oriented measures suggests the need to follow a strategic mix of infrastructural development and community empowerment to combat the potential adverse impacts of SLR in Egypt's North Coast and Delta.

7.3 Concluding Insights

This report explores the complex relationship between SLR and SDM along Egypt's North Coast and Delta. It is guided by a framework (Section 3.1) to explain how SLR causes damage to ecosystems and economic sectors, which in turn disrupts livelihoods. This disruption forces individuals facing basic insecurities—such as limited access to water, food, healthcare, income, or education—to adopt various coping mechanisms, including migration, seeking alternatives, or protesting. The report provides valuable insights into the far-reaching key social impacts of SLR.

This report presents innovative perspectives, offering a bold first step in exploring a largely unexamined and under-researched area (Hauer et al., 2020). GIS analysis grounded on the findings of the Egypt SLR Hackathon identified the potentially affected population and Egypt's key SLR focal regions for SDM: Alexandria, Port Said, Damietta, Kafr El-Sheikh, Beheira, and Dakahlia. These governorates are already experiencing early signs of vulnerability, including incidents of extreme flooding and gradual livelihood losses, prompting individuals to adopt different coping strategies as indicated by scientific literature, press archives, and expert interviews.

During the Hackathon, 36 participants answered a questionnaire that collected their insights on how affected communities cope with livelihood losses. All participants have academic backgrounds at the university level or higher and work in fields related to water and the environment. The vast majority hold respectable positions in water- and environment-related governmental institutions, companies, and projects. Most come from middle-class families and have either conducted fieldwork among various communities in Egypt's North Coast and Delta or have personal connections with these communities.

Building on the GIS analysis, questionnaire results indicate the total numbers presented in Table 7 for specific coping mechanisms across Egypt SLR focal regions for SDM. The numbers are based on the rapid assessments carried out by the Hackathon teams. Therefore, results should be considered indicative rather than precise.

Table 7 Distribution of Affected Population per Coping Mechanism

	Total Number (Million)						
SLR (2100)	**Do Nothing**	**Search for Alternative Economic Opportunities**	**Use Household Adaptation Measures**	**Internal Migration**	**External Migration**	**Protests**	**Violence**
0.5 m	0.41	15.50	1.60	9.31	6.52	3.80	0.68
1.0 m	0.71	18.58	2.27	11.56	8.25	4.16	0.76
1.5 m	1.35	25.39	4.13	16.60	12.68	4.71	0.94
2.0 m	2.36	30.74	5.52	21.22	15.87	4.87	0.99

Results indicate that 'Searching for Alternative Economic Opportunities' within the same location received the highest number of responses, suggesting that individuals primarily adapt by seeking new opportunities without relocating. This is followed by 'Internal Migration' and 'External Migration,' with internal migration being slightly more common than external migration.

The report reveals that violence and protests will be concentrated in Alexandria and Port Said, primarily driven by younger and middle-aged men facing financial pressures and distrust in the government. External migration, notably among young men and mostly in Damietta and Kafr El-Sheikh, will be influenced by financial needs and knowledge of SLR risks, and supported by social networks. External migration numbers underscore significant concerns, as they reveal a trend approximately double that of the current external migration trend from Egypt. Internal migration will be prevalent in Beheira and Dakahlia, involving both men and women, with decisions driven by financial needs and supported by social networks. These numbers are approximately 1.3 times the existing rate of internal migration.

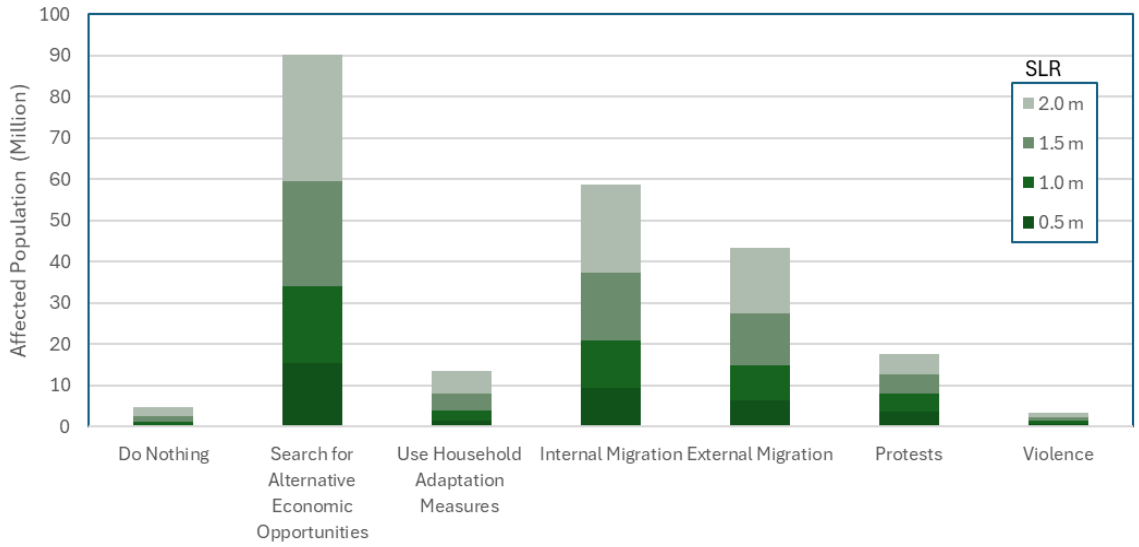


Figure 37 Distribution of affected population per coping mechanism

The use of household adaptation measures and the search for alternative economic opportunities within the same location will be common across all governorates, reflecting a broader response to the pressures imposed by SLR. Lastly, the passive reaction of "doing nothing" will be most evident in Beheira and Dakahlia, particularly among middle-aged women with lower education levels. SDM-related impacts of SLR will potentially extend beyond directly impacted areas, affecting not only areas expected to be seasonally or perennially affected by 2100 or experience deteriorating services but also the rest of Egypt and neighbouring countries.

However, the report acknowledges the inherent uncertainties and limitations of studying the complex, interconnected, and context-specific relationship between SLR and SDM. SDM is ultimately shaped by decisions made by individuals. These decisions are influenced by each person's unique characteristics, perceptions, and living conditions (Flahaux & De Haas, 2016; Schewel et al., 2024). In addition, the slow-onset nature of SLR can significantly change regional dynamics, population growth, and migration trends over time, completely altering the potential numbers provided here. This complexity makes it difficult to identify SLR as the sole driver of SDM in specific incidents.

In conclusion, the findings highlight insights and uncertainties in key SDM-related impacts of SLR in Egypt. It is confirmed that the identified governorates are vital SLR focal regions for SDM. These focal regions are already facing livelihood deterioration that will further exacerbate due to SLR. In addition, individuals with specific characteristics, living in the identified focal regions, will potentially adopt the

discussed coping mechanisms in response to livelihood losses caused by SLR. Yet, the timing of these responses remains uncertain. In contrast, the reliability of the projected numbers requires further research and modelling, as the current projections stem from hackathon results and lack comprehensive validation. Additional research will clarify these uncertainties as SLR and its impacts unfold.

Given the critical importance of Egypt's North Coast and Delta to the nation's economy—particularly in supporting key agricultural and economic activities—this report underscores the urgent need for more detailed and comprehensive studies. These studies should thoroughly investigate the context, including modelling-based projections of future impacts, the evolution of coping mechanisms, and the extent of social disruption, to better understand the potential SDM-related SLR impacts in Egypt. Comprehensive studies pave the way for effective management, planning, and governance, which can reduce climate change-related SDM by up to 80% (Clement et al., 2021). For example, a recent case study on the French coastline demonstrated that regular beach renourishment combined with appropriate household adaptation measures can decrease SLR-related migration by as much as 36% (Tierolf et al., 2024).

This report offers a foundational perspective, paving the way for more detailed and comprehensive studies in the future. It provides rough, quantifiable estimations of key potential SDM-related responses to SLR in Egypt's North Coast and Delta, rather than precise figures for design or modelling. The primary goal is to underscore the gravity of the issue and the urgent need for more detailed research in each SLR focal region. Research should include longitudinal studies to track long-term effects, advanced quantitative modelling to assess damage, and vulnerability assessments to understand the risks faced by different communities. Research should also explore the effectiveness of adaptation and mitigation strategies, and the role of policy and governance in managing SLR impacts. This report is a key starting point to spark important discussions and encourage further research, rather than providing definitive numerical assessments.

8 References

Abou-Mahmoud, M. M. E. (2021). Assessing coastal susceptibility to sea-level rise in Alexandria, Egypt. The Egyptian Journal of Aquatic Research, 47(2), 133-141.

Abou Kamar, M., Aliane, N., Elbestawi, I., Agina, M. F., & Alsetoohy, O. (2023). Are coastal hotels ready for climate change? The case of Alexandria, Egypt. International journal of environmental research and public health, 20(6), 5143.

Ahmed, O., Abdel-Salam, S., & Rungsuriyawiboon, S. (2020). Measuring the economic performance of mixed crop-livestock farming systems in Egypt: A non-parametric DEA approach. New Medit, 19(2), 133-145.

Ayazi, H., & Elsheikh, E. (2019). Climate Refugees: The Climate Crisis and Rights Denied. Retrieved from https://belonging.berkeley.edu/sites/default/files/climate_refugees.pdf

Badreldin, N., Abu Hatab, A., & Lagerkvist, C.-J. (2019). Spatiotemporal dynamics of urbanization and cropland in the Nile Delta of Egypt using machine learning and satellite big data: Implications for sustainable development. Environmental monitoring and assessment, 191, 1-23.

Barua, P., Rahman, S. H., & Molla, M. H. (2017). Sustainable adaptation for resolving climate displacement issues of south eastern islands in Bangladesh. International Journal of Climate Change Strategies and Management, 9(6), 790-810.

Beck, U. (2016). The metamorphosis of the world: How climate change is transforming our concept of the world: John Wiley & Sons.

Black, R., Arnell, N., & Dercon, S. (2011). Migration and global environmental change-review of drivers of migration. Global Environmental Change, 21(Supplement 1).

Burrows, K., & Kinney, P. L. (2016). Exploring the climate change, migration and conflict nexus. International journal of environmental research and public health, 13(4), 443.

Busby, J. (2018). Taking stock: The field of climate and security. Current Climate Change Reports, 4, 338-346.

Cai, R., Feng, S., Oppenheimer, M., & Pytlikova, M. (2016). Climate variability and international migration: The importance of the agricultural linkage. Journal of Environmental Economics and Management, 79, 135-151.

CAPMAS. (2010). Central Agency for Public Mobilization and Statistics: Fish Production. Retrieved from https://censusinfo.capmas.gov.eg/Metadata-en-v4.2/index.php/catalog?&page=11

CAPMAS. (2020). Central Agency for Public Mobilization and Statistics: Fish Production. Retrieved from https://censusinfo.capmas.gov.eg/Metadata-en-v4.2/index.php/catalog?&page=11

CAPMAS. (2022). Central Agency for Public Mobilization and Statistics: Total Agricultural Land. Retrieved from https://www.capmas.gov.eg/Pages/IndicatorsPage.aspx?Ind_id=2359. https://www.capmas.gov.eg/Pages/IndicatorsPage.aspx?Ind_id=2359

CAPMAS. (2023). Central Agency for Public Mobilization and Statistics: Population. Retrieved from https://www.capmas.gov.eg/Pages/populationClock.aspx

Chun, J., & Sang, L. (2012). Research and Policy Dialogue on Climate Change, Migration and Resettlement in Vietnam. UNDP, Vietnam.

Clement, V., Rigaud, K. K., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., . . . Shabahat, E. (2021). Groundswell Part 2.

De Haas, H. (2021). A theory of migration: the aspirations-capabilities framework. Comparative migration studies, 9(1), 8.

Dooley, H. J. (2016). Port Said, Egypt: Canal Gateway to Global Hub? Retrieved from https://worldhistoryconnected.press.uillinois.edu/13.1/forum_dooley.html

Egypt State Information Service. (2022). Dakahlia Governorate. Retrieved from https://www.sis.gov.eg/Story/235672/%D9%85%D8%AD%D8%A7%D9%81%D8%B8%D8%A9-%D8%A7%D9%84%D8%AF%D9%82%D9%87%D9%84%D9%8A%D8%A9?lang=ar#:~:text=%D8%AA%D8%A8%D9%84%D8%BA%20%D9%85%D8%B3%D8%A7%D8%AD%D8%A9%20%D9%85%D8%AD%D8%A7%D9%81%D8%B8%D8%A9%20%D8%A7%D9%84%D8%AF%D9%82%D9%87%D9%84%D9%8A%D8%A9%203538.2,%D8%A7%D9%84%D9%85%D8%B3%D8%A7%D8%AD%D8%A9%20%D8%A7%D9%84%D9%85%D9%86%D8%B2%D8%B1%D8%B9%D8%A9%20%D8%B9%D9%84%D9%89%20%D9%85%D8%B3%D8%AA%D9%88%D9%89%20%D8%A7%D9%84%D8%AC%D9%85%D9%87%D9%88%D8%B1%D9%8A%D8%A9%20.

El-Masry, E. A., El-Sayed, M. K., Awad, M. A., El-Sammak, A. A., & Sabarouti, M. A. E. (2022). Vulnerability of tourism to climate change on the Mediterranean coastal area of El Hammam–EL Alamein, Egypt. Environment, Development and Sustainability, 24(1), 1145-1165.

Ericson, J. P., Vörösmarty, C. J., Dingman, S. L., Ward, L. G., & Meybeck, M. (2006). Effective sea-level rise and deltas: Causes of change and human dimension implications. Global and Planetary Change, 50(1-2), 63-82.

Fahim, N., Abdel-Salam, S., Mekkawy, W., Ismael, A., Abo Bakr, S., El Sayed, M., & Ibrahim, M. A. (2018). Delta and upper Egypt buffalo farming systems: a survey comparison. Egyptian Journal of Animal Production, 55(2), 95-106.

FAO. (2020). Country Profile - Egypt. Retrieved from https://www.fao.org/countryprofiles/index/en/?iso3=EGY

FAO. (2024a). Egypt at a glance. Retrieved from https://www.fao.org/egypt/our-office/egypt-at-a-glance/en/

FAO. (2024b). Scaling up Climate Ambition on Land Use and Agriculture through Nationally Determined Contributions and National Adaptation Plans (SCALA) Retrieved from https://www.fao.org/in-action/scala/countries/egypt/en

FAOSTAT, F. (2016). Agriculture Organization of the United Nations Statistics division. Economic and Social Development Department, Rome, Italy. Available online: http://faostat3. fao. org/home/E (accessed on 31 December 2016).

Ferrando, M. (2023). Fish Farmers in the Nile River Delta: Empty Lakes and Dirty Waters. Retrieved from https://www.mei.edu/sites/default/files/2023-05/MFerrando%20-%20Fish%20Farmers%20in%20the%20Nile%20Delta.pdf

Flahaux, M.-L., & De Haas, H. (2016). African migration: trends, patterns, drivers. Comparative migration studies, 4, 1-25.

Gibson, N., McNulty, S., Miller, C., Gavazzi, M., Worley, E., Keesee, D., & Hollinger, D. (2021). Identification, mitigation, and adaptation to salinization on working lands in the US Southeast: Forest Service, US Department of Agriculture, Southern Research Station.

GlobWetland Africa. (2022). Lake Burullus: Fact Sheet. Retrieved from http://globwetland-africa.org/wp-content/uploads/2022/05/8.-FactSheet_IR_Lake_Burullus_final.pdf

Ha Noi, U. V. N. (2014). Migration, Resettlement and Climate Change in Viet Nam: Reducing Exposure and Vulnerabilities to Climatic Extremes and Stresses through Spontaneous and Guided Migration. Retrieved from https://www.undp.org/sites/g/files/zskgke326/files/migration/vn/Migration-and-climate-change_BW.pdf

Hammam, A., & Mohamed, E. (2020). Mapping soil salinity in the East Nile Delta using several methodological approaches of salinity assessment. The Egyptian Journal of Remote Sensing and Space Science, 23(2), 125-131.

Hauer, M. E., Fussell, E., Mueller, V., Burkett, M., Call, M., Abel, K., . . . Wrathall, D. (2020). Sea-level rise and human migration. Nature Reviews Earth & Environment, 1(1), 28-39.

Hossain, B., Shi, G., Ajiang, C., Sarker, M. N. I., Sohel, M. S., Sun, Z., & Yang, Q. (2022). Climate change induced human displacement in Bangladesh: Implications on the livelihood of displaced riverine island dwellers and their adaptation strategies. Frontiers in psychology, 13, 964648.

IDMC. (2021). Global Report on Internal Displacement 2021. *Retrieved from https://www.internal-displacement.org/global-report/grid2021/*

IPCC. (2021). 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_FrontMatter.pdf

IPDC. (2025). Egypt Sea Level Rise Hackathon: Exploring Process, Challenges, and Solutions. International Panel on Deltas and Coastal Areas. *(Manuscript in preparation)*

Jevrejeva, S., Moore, J., Grinsted, A., Matthews, A., & Spada, G. (2014). Trends and acceleration in global and regional sea levels since 1807. Global and Planetary Change, 113, 11-22.

Jónsson, G. (2010). The environmental factor in migration dynamics-a review of African case studies.

Kangmennaang, J., Bisung, E., & Elliott, S. J. (2020). 'We are drinking diseases': Perception of water insecurity and emotional distress in urban slums in Accra, Ghana. International journal of environmental research and public health, 17(3), 890.

Leal, A. S., & Huaman, M. G. (2019). Migration, environment and climate change in coastal cities in Indonesia. IOM Policy Brief, Series, 2(5).

Lubkemann, S. C. (2008). Involuntary immobility: on a theoretical invisibility in forced migration studies. Journal of Refugee Studies, 21(4), 454-475.

Mahmoud, T., Patrahau, I., & Vignali, A. (2023). Understanding the pathways from water insecurity to urban migration in southern Iraq. Retrieved from https://waterpeacesecurity.org/files/314

Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari. (2019). Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate Retrieved from https://doi.org/10.1017/9781009157964.006.

Perez, N. D., Kassim, Y., Ringler, C., Thomas, T. S., ElDidi, H., & Breisinger, C. (2021). Climate-resilience policies and investments for Egypt's agriculture sector: Sustaining productivity and food security: Intl Food Policy Res Inst.

Pommells, M., Schuster-Wallace, C., Watt, S., & Mulawa, Z. (2018). Gender violence as a water, sanitation, and hygiene risk: Uncovering violence against women and girls as it pertains to poor WaSH access. Violence against women, 24(15), 1851-1862.

Reimann, L., Jones, B., Bieker, N., Wolff, C., Aerts, J. C., & Vafeidis, A. T. (2023). Exploring spatial feedbacks between adaptation policies and internal migration patterns due to sea-level rise. nature communications, 14(1), 2630.

Rigaud, K. K., Clement, V., de Sherbinin, A., Jones, B., Adamo, S., Schewe, J., . . . Shabahat, E. (2018). Groundswell Part 1.

Salem, M., Tsurusaki, N., & Divigalpitiya, P. (2020). Remote sensing-based detection of agricultural land losses around Greater Cairo since the Egyptian revolution of 2011. Land Use Policy, 97, 104744.

Scheffran, J., Brzoska, M., Kominek, J., Link, P. M., & Schilling, J. (2012). Disentangling the climate-conflict nexus: Empirical and theoretical assessment of vulnerabilities and pathways. Rev. Eur. Stud., 4, 1.

Schewel, K., Dickerson, S., Madson, B., & Nagle Alverio, G. (2024). How well can we predict climate migration? A review of forecasting models. Frontiers in Climate, 5, 1189125.

Schrijvers, E., Prins, C., Passchier, R., Schrijvers, E., Prins, C., & Passchier, R. (2021). Societal Disruption. Preparing for Digital Disruption, 9-16.

Sen, K., & Hickey, S. (2024). Pathways to Development: From Politics to Power: Oxford University Press.

Statista. (2024a). Production volume of main crops in Egypt in 2021. Retrieved from: https://www.statista.com/statistics/1063560/egypt-main-crops-by-production-volume/

Statista. (2024b). Stock of emigrants from Egypt in 2020, by country of destination. Retrieved from: https://www.statista.com/statistics/1237586/stock-of-emigrants-from-egypt-by-country-of-destination/

Stevenson, E. G., Greene, L. E., Maes, K. C., Ambelu, A., Tesfaye, Y. A., Rheingans, R., & Hadley, C. (2012). Water insecurity in 3 dimensions: an anthropological perspective on water and women's psychosocial distress in Ethiopia. Social science & medicine, 75(2), 392-400.

Stoler, J., Brewis, A., Kangmennang, J., Keough, S. B., Pearson, A. L., Rosinger, A. Y., . . . Stevenson, E. G. (2021). Connecting the dots between climate change, household water insecurity, and migration. Current Opinion in Environmental Sustainability, 51, 36-41.

Tallman, P. S., Collins, S., Salmon-Mulanovich, G., Rusyidi, B., Kothadia, A., & Cole, S. (2023). Water insecurity and gender-based violence: A global review of the evidence. Wiley Interdisciplinary Reviews: Water, 10(1), e1619.

The World Bank Group and Asian Development Bank. (2021). Climate Risk Profile: Indonesia. Retrieved from https://climateknowledgeportal.worldbank.org/sites/default/files/2021-05/15504-Indonesia%20Country%20Profile-WEB_0.pdf

Tiboris, M. (2020). Water Insecurity and Climate Change as Emerging Human Migration Pressures. Loy. U. Chi. Int'l L. Rev., 16, 87.

Tierolf, L., Haer, T., Athanasiou, P., Luijendijk, A. P., Botzen, W. W., & Aerts, J. C. (2024). Coastal adaptation and migration dynamics under future shoreline changes. Science of the Total Environment, 917, 170239.

UN. (2024). Human Settlements on the Coast, UN Atlas of the Oceans Retrieved from http://www.oceansatlas.org/subtopic/en/c/114/. http://www.oceansatlas.org/subtopic/en/c/114/

UNDP. (2023). Battling Climate Change with Climate-Smart Crops in Egypt. Retrieved from https://www.undp.org/egypt/blog/battling-climate-change-climate-smart-crops-egypt

UNDRR. (2021). Protecting the Nile delta. Retrieved from https://www.preventionweb.net/news/protecting-nile-delta

UNFCC. (2015). Nationally determined contribution- Egypt. Retrieved from https://unfccc.int/NDCREG

United Nations. (2022). Five ways the climate crisis impacts human security. Retrieved from https://www.un.org/en/climatechange/science/climate-issues/human-security

Voiland, A. (2024). The Nile Delta's Disappearing Farmland. Retrieved from https://earthobservatory.nasa.gov/images/149183/the-nile-deltas-disappearing-farmland

World Bank. (2017). Beyond Scarcity: Water Security in the Middle East and North Africa: The World Bank.

World Bank. (2022). Egypt: Country Climate and Development Report. Retrieved from https://reliefweb.int/report/egypt/egypt-country-climate-and-development-reportnovember-8-2022enargad_source=&gclid=CjwKCAjwnK60BhA9EiwAmpHZw3z_KIlREcDMtC19rd9jZ3wO7L3mtdsDjzFw5WTb0a62_6DuJ27hoCwxYQAvD_BwE

Wutich, A., & Brewis, A. (2014). Food, water, and scarcity: toward a broader anthropology of resource insecurity. Current Anthropology, 55(4), 444-468.

Wutich, A., Brewis, A., & Tsai, A. (2020). Water and mental health. In: WIREs Water.

Zaveri, E., Russ, J., Khan, A., Damania, R., Borgomeo, E., & Jägerskog, A. (2021). Ebb and Flow, Volume 1. In: Washington, DC: World Bank.

9 Supplementary References

Abdelbary, A. (2018). More than 10 Meters of Sea Level Rise in Ras El-Bar. Retrieved from https://www.youm7.com/story/2018/1/19/%D8%A7%D8%B1%D8%AA%D9%81%D8%A7%D8%B9-%D9%85%D9%86%D8%B3%D9%88%D8%A8-%D9%85%D9%8A%D8%A7%D9%87-%D8%A7%D9%84%D8%A8%D8%AD%D8%B1-%D8%A8%D8%B4%D9%88%D8%A7%D8%B7%D8%A6-%D8%B1%D8%A3%D8%B3-%D8%A7%D9%84%D8%A8%D8%B1-%D9%84%D8%A3%D9%83%D8%AB%D8%B1-%D9%85%D9%86-10/3609043. [Media Report]

Ahram Online. (2017). Egyptian authorities foil attempt by 47 people to migrate to Europe. Retrieved from https://english.ahram.org.eg/News/275640.aspx. [Media Report]

Al-Ragehy, E. (2024) Social Disruption and Migration Due to Sea Level Rise in the Egyptian North Coast and Delta- Egypt SLR Hackathon Event/Interviewer: M. T. [Primary Interview]

Aldekoa, X., & Aragó, L. (2023). Chapter 2: Alexandria is Dying of Salt. Retrieved from https://earthjournalism.net/stories/egypts-nile-delta-under-threat-part-1-the-sea-engulfs-kafr-el-sheikh. [Media Report]

Ali, M. (2024) Social Disruption and Migration Due to Sea Level Rise in the Egyptian North Coast and Delta- Egypt SLR Hackathon Event/Interviewer: M. T. [Primary Interview]

Blata, I. (2024) Social Disruption and Migration Due to Sea Level Rise in the Egyptian North Coast and Delta- Egypt SLR Hackathon Event/Interviewer: M. T. [Primary Interview]

Changpertitum, K. (2015). Migrants face dangerous journey from Egypt to Italy. Daily News Egypt. Retrieved from https://www.dailynewsegypt.com/2015/02/01/migrants-face-dangerous-journey-egypt-italy/. [Media Report]

Egypt Today. (2021a). Families of 120 fishermen detained in Eritrea call for their release. Egypt Today. *Retrieved from https://www.egypttoday.com/Article/1/97218/Families-of-120-fishermen-detained-in-Eritrea-call-for-their. [Media Report]*

Egypt Today. (2021b). Saudi Arabia releases Egyptian boat seized for fishing in its waters. Egypt Today. *Retrieved from https://www.egypttoday.com/Article/1/96720/Saudi-Arabia-releases-Egyptian-boat-seized-for-fishing-in-its. [Media Report]*

Egypt Today. (2021c). Tunisia seizes 2 Egyptian fishing boats after entering territorial waters. Egypt Today. *Retrieved from https://www.egypttoday.com/Article/1/95964/Tunisia-seizes-2-Egyptian-fishing-boats-after-entering-territorial-waters. [Media Report]*

EL-Attar, A. S. (2023). A target of 1.5 degrees Celsius or the drowning of 21 cities in Egypt's Delta. "A data-driven investigation". Retrieved from https://ozoneeg.net/2023/09/28/%D8%BA%D8%B1%D9%82-21-%D9%85%D8%AF%D9%8A%D9%86%D8%A9-%D8%A8%D8%AF%D9%84%D8%AA%D8%A7-%D9%85%D8%B5%D8%B1/#:~:text=%D9%81%D9%8A%202019%D8%8C%20%D9%82%D8%A7%D9%84%20%D8%AA%D9%82%D8%B1%D9%8A%D8%B1%20%D9%84%D9%85%D8%B1%D9%83%D8%B2,%D9%85%D8%B9%20%D8%AA%D9%88%D9%82%D8%B9%D8%A7%D8%AA%20%D8%A8%D8%AA%D9%81%D8%A7%D9%82%D9%85%20%D8%A7%D9%84%D9%85%D8%B4%D9%83%D9%84%D8%A9%20%D9%85%D8%B3%D8%AA%D9%82%D8%A8%D9%84%D9%8B%D8%A7. [Media Report]

El-Koumy, Y. (2024) Social Disruption and Migration Due to Sea Level Rise in the Egyptian North Coast and Delta- Egypt SLR Hackathon Event/Interviewer: M. T. [Primary Interview]

ElSafty, S., & Saafan, F. (2022). Insight: Egypt's Nile Delta farmland salts up as temperatures, and seas, rise. Retrieved from https://www.reuters.com/business/cop/egypts-nile-delta-farmland-salts-up-temperatures-seas-rise-2022-11-17/. [Media Report]

Emam, A. (2018). Egyptian province shows fish farming better lure than migration. Retrieved from https://thearabweekly.com/egyptian-province-shows-fish-farming-better-lure-migration. [Media Report]

Farouk, M. A. (2022). Egypt erects sand barriers as rising sea swallows the Nile Delta. Retrieved from https://www.preventionweb.net/news/egypt-erects-sand-barriers-rising-sea-swallows-nile-delta. [Media Report]

Joshi, D., Dessouki, A., & Lahham, N. (2022). Staying alive: Navigating water, gender and poverty inequalities in Kafr El Sheikh, Egypt. Retrieved from https://www.iwmi.cgiar.org/blogs/staying-alive-navigating-water-gender-and-poverty-inequalities-in-kafr-el-sheikh-egypt/. [Media Report]

Mounir, E. (2023a). Egypt's Nile Delta Under Threat, Part 1: The Sea Engulfs Kafr El-Sheikh. Retrieved from https://earthjournalism.net/stories/egypts-nile-delta-under-threat-part-1-the-sea-engulfs-kafr-el-sheikh. [Media Report]

Mounir, E. (2023b). Egypt's Nile Delta Under Threat, Part 2: Can the Country Reclaim What It's Lost? Retrieved from https://earthjournalism.net/stories/egypts-nile-delta-under-threat-part-1-the-sea-engulfs-kafr-el-sheikh. [Media Report]

Team Blue. (2024). Egypt SLR Hackathon Report: Health and Environment. Retrieved from Deltares, Delft, The Netherlands. [Unpublished Internal Report]

Team Green. (2024). Egypt SLR Hackathon Report: Agriculture. Retrieved from Deltares, Delft, The Netherlands. [Unpublished Internal Report]

Team Grey. (2024). Egypt SLR Hackathon Report: Infrastructure. Retrieved from Deltares, Delft, The Netherlands. [Unpublished Internal Report]

A Annex A: Serious Game

"Rising Tides"

A Social Impact Challenge

A.1 Mission and Vision

Among the main tasks of the cross-domain expert on social disruption and migration (SDM) is to ensure that the 2024 Egypt sea level rise (SLR) Hackathon event teams consider the social implications of their proposed measures in their respective tasks and to identify the possible social disruption and migration (SDM)-related impacts of SLR within different Egyptian demographic groups.

Most Hackathon participants are experts on technical aspects, yet many of them have performed field studies among Egyptian local communities, while others have personal connections within those communities. Their interaction with local communities holds invaluable insights if translated into the social determinants of SDM.

Therefore, this serious game was designed as a means, first to simplify to the hackathon participants the linkages between SLR and SDM and, second to harvest their insights indirectly, yet effectively. Those Insights are to be used in the study report on SLR-related SDM in Egypt.

The game utilizes an analysis framework adopted and modified from a report published by the Water, Peace and Security program – detailed in Section 3.1 (Mahmoud et al., 2023). The game introduces participants to the theoretical framework by familiarizing them with its components and encouraging them to make decisions during gameplay that reveal the complex, interconnected, and context-specific factors of SDM-related impacts of SLR. This interactive approach allows participants to explore the linkages between SLR and SDM practically and engagingly.

Many participants, while knowledgeable about community interactions, may not fully grasp or relate to the social ramifications of biophysical phenomena due to a lack of exposure to relevant terminology and scientific explanations. Instead of relying on traditional lectures, which might be less convincing, the game enables participants to uncover these connections themselves. This hands-on experience helps them internalize the relationships between SLR and SDM, making the insights more impactful and relatable.

A.2 Execution During the Hackathon

The game was to be played during "Day 2 (27 February 2024): Task A". The game should have taken about 25-30 minutes with each team individually, considering teams consist of 5-7 members. However, a few rounds were played with all the teams simultaneously due to time limitations. This provided participants with an understanding of the theoretical framework; however, it did not fully capture the necessary insights. Instead, this objective was thoroughly addressed through the questionnaire and expert interviews- detailed in Annex B.

A.3 Objective

The game has two objectives. First, the game helps participants grasp and visualize the theoretical framework, enabling them to better understand the complex, interconnected, and context-specific factors driving SLR-related SDM. It educates them about the determinants of communities' adaptive capacity and types of coping mechanisms in the context of SLR. Second, the game should grasp the knowledge they have gained while working/

interacting with local communities. This is achieved by having the moderator observe and record participants' moves that reflect specific community coping mechanisms. Since all the game cards are based on real communities, the gameplay allows participants to connect their practical experiences with the strategies and challenges represented, fostering a deeper understanding of these coping mechanisms.

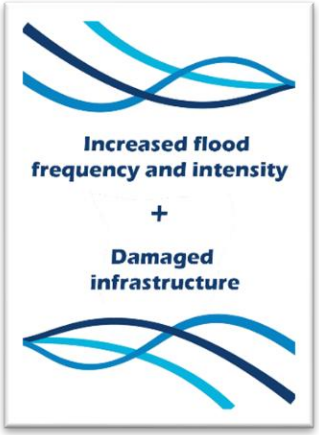
A.4 Game Description

This is a circular card game played among a group of players. Each player draws three cards that together describe a situation and selects three actions from three distinct lists of available choices, as outlined below.:

A.4.1 *Turns*

1. The first Player draws a "***Rising Community***" card.
   - In this card set, each card represents a different type of community, outlining key characteristics, demographics, and existing vulnerabilities.
   - Communities include:
     i. Farmers.
     ii. Fishermen.
     iii. Public sector workers.
     iv. Private sector workers.
     v. Daily wage workers.

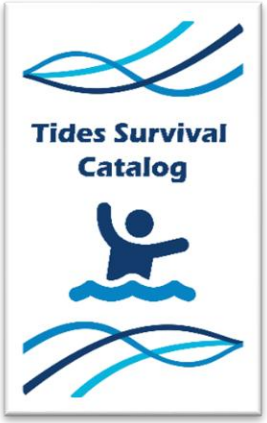
2. The player is to choose another team member who he/she believes is most experienced with the "*Rising Community*" card he has drawn. 10 secs
3. The rest of the team is to be the jury that will rank the player's actions based on a scale of "Very Realistic (score +1)", "Realistic (score 0)" or "Doubtable (score -1)".
4. The player draws a "**Stressor *Tides***" card. 10 secs
   - In this card set, each card contains a scenario of a hydraulic stressor combined with a scenario of a socio-economic stressor.
   - Hydraulic stressors include:
     i. Increased flood frequency and intensity.
     ii. Increased inundation levels.
     iii. Shoreline advancement.
     iv. Salt intrusion to GW wells.
     v. Salt intrusion to water plants' intake points.
     vi. Soil Salinization



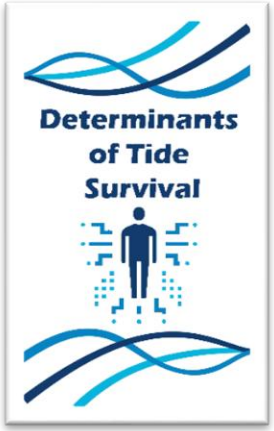
   - socio-economic stressors include:
     i. Population growth rate.
     ii. Water pollution practices.
     iii. Inefficient consumption.
     iv. Damaged infrastructure.
5. The player draws an "***Authority Ailment***" card. 10 secs
   - In this card set, each card has a negative coping mechanism performed by the authority such as:

i. Inefficient or no flood protection.
ii. Inefficient or no beach renourishment.
iii. Inefficient or no International investment.
iv. Inefficient or no foreign aid.
v. Weak political System and institutional capacity.
vi. Lack of social equity.

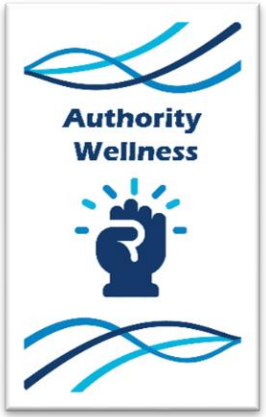
6. The player has one minute to choose (after discussing with the team member he chose in step 2) one from a list called "***Tides Survival Catalog***". 60 secs
   - This list includes individual coping mechanism strategies such as:
     i. Do Nothing.
     ii. Search for alternative economic opportunities.
     iii. Use household adaptation measures.
     iv. Protests.
     v. Riots.
     vi. Internal Migration.
     vii. External Migration.
7. The player has to match his choice from the *"Tides Survival Catalog"* with two from a "***Determinants of Tide Survival***" list. 60 secs



   - This list includes determinants of individual adaptive capacity such as:
     i. GDP.
     ii. Age.
     iii. Gender.
     iv. Social networks.
     v. Government subsidies.
     vi. Financial capital.
     vii. Perception of SLR hydraulic risk.
     viii. Perception of governmental capacity and responses.



8. Each of the jury rates, and the rates are summed (according to step 3). 90 secs
9. The player has one minute to choose one from a list called "***Authority Wellness***" 60 secs
   - This list includes positive coping mechanisms performed by the authority such as:
     i. Effective flood protection.
     ii. Regular beach renourishment.
     iii. Working towards more international investment.
     iv. Advertising for the impacts of SLR to get foreign aid.
     v. Enhanced political system and institutional capacity.
     vi. Promoting social equity.
     vii. Promoting special education.
     viii. Subsidies for resilient housing.



10. The player has another minute to match his choice from the *"Authority Wellness"* list with two from the "*Determinants of Tide Survival"* (step 7). **60 secs**
11. Each of the jury rates (according to step 3) and the rates are summed. **10 secs**
12. The game ends when all team players have played.

A.4.2 *Collaboration and Scoring*

Players are encouraged to discuss and defend their choices in the game (in steps 6,7, 9, 10). This is to have brief yet positive discussions about their views on the social determinants of SLR-related SDM and mitigation pathways to create resilient communities.

The player with the highest sum of points is the winner. All players' choices and important points of discussion are noted and used as insights for the report.

B Annex B: Questionnaire and Expert Interviews

B.1 Mission and Vision

One of the primary roles of the cross-domain expert in social disruption and migration (SDM) is to assess the possible social disruption and migration (SDM)-related impacts of SLR within different Egyptian demographic groups. Therefore, a questionnaire and expert interviews were developed to capture insights from hackathon participants.

The interviews were structured to align with the flow of the theoretical framework detailed in Section 3.1, with questions designed to reflect its content. The interviews were conducted after participants played the serious game- detailed in Annex A. The game familiarized the participants with the framework's components, ensuring that their responses during the interview were informed and contextually relevant.

The interviews incorporate structured questions and open-ended discussions, allowing experts to expand on their insights and share relevant expertise. Experts from the hackathon group were selected for interviews based on the depth of their on-ground experience with communities.

The questionnaire mirrored the structure of the expert interviews but used multiple-choice questions. A total of 36 participants answered the questionnaire. Participants could complete the questionnaire in person, which most opted to do, enabling further elaboration and discussion. This approach also helped identify additional experts for semi-structured interviews. The questionnaire and expert interviews were conducted throughout all the event days. A list of Participants in the questionnaire and interviews is available in Annex C.

B.2 Objective and Execution

The primary objective of the questionnaire and expert interviews was to capture insights and knowledge that hackathon participants have gained through their work or interactions with local communities. This approach complements the serious game, especially given the time constraints.

Participants began by selecting a community from a list identified as vulnerable to SLR, either currently or in the future. They then indicated whether their responses were based on personal familiarity, professional experience, or general knowledge. Following the theoretical framework outlined in this report, participants answered questions to provide an overview of the community's situation.

Next, they described the community's responses to SLR and deteriorating livelihoods, specifying whether their answers were informed by personal or professional experiences, anticipated future responses based on their interactions with the community, or general perceptions. This distinction helped clarify whether their responses were rooted in firsthand experience, professional expertise, or general assumptions, ensuring a clear understanding of the reasoning behind each answer.

Finally, participants offered opinion-based suggestions for effective mitigation measures.

B.3 Questions

The following are the questions used for both the questionnaire and expert interviews. While the questionnaire utilized structured responses, the expert interviews adapted these questions to an open-ended format, enabling experts to elaborate on their insights and share relevant expertise.

Select a community (and its location) with which you have prior experience or familiarity

Example: *Farmers in Kafr Al-Sheikh*

Farmers	in port said
Fishermen	in Ismailia
Public sector workers	in Damietta
Private sector workers	in Sharkia
Daily wage workers	in Dakahlia
Small business owners	in Kafr Al-Sheikh
Bedouins/ Nomads (عرب/ بدو)	in Alexandria
Household head women on subsidies	in Beheira
	in North Sinai
	in Marsa Matruh

How do you know that community?

Professional experience
Common knowledge
Personal familiarity

Stresses

*Pick **two** choices that best describe the most pressing **biophysical stresses** this community experiences.*

Increased rainfall frequency and intensity
Increased inundation levels
Shoreline erosion
Salt intrusion to GW wells
Salt intrusion to surface water
Soil salinization

If "other" please mention		

*Pick **two** choices that best describe the most pressing **other stresses** this community experiences*.

Overpopulation
Water pollution practices by local communities
Water pollution practices by the commercial sectors
Inefficient use of natural resources by local communities (water, land…etc.)
Inefficient use of natural resources by the commercial sectors (water, land…etc.)
Insufficient or no foreign aid
High crime rate
Inadequate institutional capacity (such as lack of funds for research, lack of training and capacity building for personnel)
Land appropriation
Other

If "Other" please mention		

Current State

*Pick **two** choices that best describe the most relevant current state of **infrastructure and ecosystems***

Inefficient or no flood protection in the coastal areas
Inefficient or no wet infrastructure inland (Such as leaky pipelines or Inefficient storm drainage)
Inefficient or no beach maintenance
Inefficient or damaged hard infrastructure (such as roads, bridges, tunnels, and railways)
Deteriorated ecosystems
Other

If "Other" please mention		

	Pick **two** choices that best describe the most relevant **current social state**		
	Lack of social equity in the distribution and management of resources		
	Increased corruption and patronage		
	Inadequate national and international water governance		
	Other		
	If "Other" please mention		
	*Pick **two** choices that best describe the most relevant **current state of individuals***		
	Insufficient quantity and/ or quality of household water		
	Food insecurity		
	Insufficient income		
	Health issues		
	Other		
	If "Other" please mention		
Response	What best describes the most likely **community response** now or in the future?		
	Do Nothing		
	Search for alternative economic opportunities		
	Use household adaptation measures (such as elevating houses or flood-proof building material)		
	Internal migration		
	External migration		
	Protests		
	Violence		
	Based on what have you chosen that community response?		

	Professional experience
	Common knowledge
	Personal familiarity
Factors	What are the most relevant **two factors** contributing to that community response?
	Financial capacity (for example: high in case of migration- low in case of protests)
	Lack of government subsidies or support
	Communities' perception of the impacts of SLR (hydraulic risk)
	Communities' perception of governmental capacity and responses to SLR
	Presence and strength of social networks (Only choose this if you have chosen "Internal Migration" or "External Migration" in the previous Q)
Community Characteristics	What is the **age** of the majority who would follow that community response?
	Youth (18-30)
	Middle-aged (31-50)
	Older citizens (>50)
	All
	What is the **gender** of the majority who will have that response?
	Male
	female
	All
	What is the **education status** of the majority who will have that community response?
	Illiterate
	Read & write

Primary
Preparatory
Secondary
University and above

Measures

Pick one or two most effective **technical and/or national measures** to mitigate the current situation.

Effective Flood protection in the coastal areas
Effective wet infrastructure inland (pipelines, storm drainage…etc.)
Resilient hard Infrastructure (such as roads, bridges, tunnels, and railways)
Regular beach renourishment
Governmental subsidies for resilient housing
Working towards more international investment to increase economic stability
Advertising for the impacts of SLR to get foreign aid
Enhanced political system and institutional capacity.
Other
None
Community-oriented measures are more relevant

If "Other" please mention		

Pick one or two most effective **community-oriented measures** to mitigate the current situation.

Relocating affected communities
Stakeholder engagement in the design processes
Promoting social equity in the management and distribution of resources

Raising awareness about the impacts of SLR
Promoting special education to provide local communities with income alternatives
Facilitating NGOs' work and communication with communities
Other
None
Technical and/or national measures are more relevant

If "Other" please mention		
If possible, provide brief reasons for your last choices		

C Annex C: Portfolio of Questionnaire Participants

Participant	Organization	Position	Experience
1	Alexandria Sanitary Drainage Company- The Egyptian Holding Company for Water & Wastewater	General Manager of Master Planning- Planning Sector	Economic feasibility studies of sewage in rural Alexandria- EIB studies of new/upgrading wastewater treatment plants
2	Coastal Research Institute- The Egyptian National Water Research Center (NWRC)	Researcher	Coastal engineering design
3	Deltares	Expert advisor	IWRM
4	Deltares	Flood and Drought Risk Specialist	National water resources planning for transboundary deltas- drought-prone regions of Egypt.
5	Deltares, and Utrecht University	Associate Professor, and Senior Hydrogeologist	Field studies, Kafr El-Sheikh, Egypt
6	Drainage Research Institute- The Egyptian National Water Research Center (NWRC)	Professor, and Deputy Director	Drainage and water quality assessments
7	Egyptian Public Authority for Shore Protection	General Manager for Research and Studies	Coastal research and studies
8	Egyptian Public Authority for Shore Protection	General Manager for Design Projects	Coastal studies and design
9	Egyptian Public Authority for Shore Protection	Head of the Egyptian Central Administration for Implementation of Red Sea	Implementation of shore protection projects
10	Enhancing Climate Change Adaptation in the North Coast and Delta Project (ECCADP)	Professor- Project Manager	Consultations on climate change and water management
11	Enhancing Climate Change Adaptation in the North Coast and Delta Project (ECCADP)	Professor- Legal and Institutional Project Officer	Strategic planning and governance consultations
12	Faculty of Engineering- Cairo University	Assistant Professor	Studies and research on water quality & management
13	Faculty of Engineering, Cairo University	Teaching Assistant- Hydrologist	Groundwater research and analysis, Siwa, Egypt

14	Faculty of Regional and Urban Planning, Cairo University, and Enhancing Climate Change Adaptation in the North Coast and Delta Project (ECCADP)	Associate Professor, and Integrated Coastal Zone Management (ICZM) Expert	Urban planning and studies on ICZM
15	Faculty of Regional and Urban Planning, Cairo University	Assistant Professor	Environmental planning research and studies
16	Mechanical and Electrical Authority, The Egyptian Ministry of Water Resources and Irrigation (MWRI)	Director of Emergency Management	Crisis and disaster management
17	Nile university	Assistant professor, and Head of Water Program	Salinization, water management research
18	Private Sector (Dar)	Groundwater Engineer	Hydrological and hydrogeological analysis
19	Private sector (Khatib & Alami)	Senior Hydrologist	Consultation and design
20	Soil, Water & Environment Research Institute (SWERI), The Egyptian Agricultural Research Center	Researcher	Studies on plant nutrition and reclamation of degraded soils
21	Soil, Water & Environment Research Institute (SWERI), The Egyptian Agricultural Research Center	Chief of Research	Studies and research on soil fertility and plant nutrition
22	The Egyptian Holding Company for Water & Wastewater	Manager of the Master Planning Department	Planning and design
23	The Egyptian Hydraulics Research Institute (HRI)	Mechanical Engineer	Pump stations, pipeline and water hammer design and calibration
24	The Egyptian Hydraulics Research Institute (HRI)	Associate Professor	Coastal and river studies and research
25	The Egyptian Ministry of Environment (EEA)	General Manager for Water Quality and Lakes	Studies on water, wastewater, and lake quality
26	The Egyptian Ministry of Environment (EEA)	Director of Laboratories in the Delta Region	Environmental research
27	The Egyptian Ministry of Water Resources and Irrigation (MWRI)	Senior Civil Engineer	Technical design

28	The Egyptian Ministry of Water Resources and Irrigation (MWRI)	Civil Engineer in the Planning Sector	Hydrology and data analysis
29	The Egyptian Ministry of Water Resources and Irrigation (MWRI)	General Director of the Water Uses Department	Studies on water resources management
30	The Egyptian National Water Research Center (NWRC)	Deputy Director	Groundwater studies and research
31	The Egyptian National Water Research Center (NWRC)	Professor	Hydroinformatics studies
32	The Egyptian National Water Research Center (NWRC)	Senior Researcher	Integrated water resources management research
33	The Environmental Affairs Agency (EEAA) - The Egyptian Ministry of Environment (EEA)	Head of Mitigation & Carbon Credits	Climate change mitigation studies
34	The World Health Organization	Mental Health Technical Officer	Community engagement studies
35	Wageningen Environmental Research	PhD Researcher	Water resources management research
36	-	Urban planner / GIS Specialist	Urban planning / GIS analysis