Civil Engineering and Architecture 10(6): 2230-2245, 2022 http://www.hrpub.org
DOI: 10.13189/cea.2022.100602

From Regional to Local Level: An Integrated Planning Framework for Cities Facing Tsunami Risk – Alexandria Case, Egypt

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Received April 11, 2022; Revised July 15, 2022; Accepted August 20, 2022

Cite This Paper in the Following Citation Styles

(a): *[1] Muhammad A. Seddeek, Maha M. Elsayed , "From Regional to Local Level: An Integrated Planning Framework for Cities Facing Tsunami Risk – Alexandria Case, Egypt," Civil Engineering and Architecture, Vol. 10, No. 6, pp. 2230-2245, 2022. DOI: 10.13189/cea.2022.100602.*

(b): *Muhammad A. Seddeek, Maha M. Elsayed (2022). From Regional to Local Level: An Integrated Planning Framework for Cities Facing Tsunami Risk – Alexandria Case, Egypt. Civil Engineering and Architecture, 10(6), 2230-2245. DOI: 10.13189/cea.2022.100602.*

Abstract The northern coast of the Mediterranean Sea is considered the most seismically active region in the world where a tsunami can occur at any moment. Alexandria is one of the biggest and most populated cities on the coast of the Mediterranean Sea and it is threatened by the tsunami. By reviewing most of the planning studies that targeted the future of Alexandria and its region, the paper finds the missing piece of an integrated planning framework that needs to be applied. The deductive method is used to infer the missing parts in the different studies to produce an integrated planning framework which consists of three phases illustrating timing response named as during, before, and after the disaster. The seven processes representing the three phases can be defined as vulnerability, assessment, planning, coping, mitigation, response, and recovery; the previous process is detailed into eight stages which are named background research, communication, risk determination, command, forecasting, prediction, emergency relief and rehabilitation. The interview technique is used to get the suggestions and the feedback from urban planning experts to improve the framework. The proposed framework will be sustained and increase awareness at the institutional level about the coastal communities at risk and put forward suggestions on how to withstand natural phenomena like tsunamis and mitigate their destructive effects.

Keywords Tsunami, Alexandria, Integrated Planning Framework, Resilient Planning Process

1. Introduction

1.1. Historical Background

The Northern Egyptian coast overlooking the Mediterranean Sea has been subjected to devastating tsunami waves. Various seismic events have been documented for the Egyptian coast, especially Alexandria, which is one of the main cities overlooking the Mediterranean. Most of the tsunami waves that affected Alexandria came from the Hellenic arc (one of the most actively destructive seismic sources of tsunami waves in the Mediterranean), located 500 km northwest of the northern coasts [1,2]. Historical sources recorded a group of marine earthquakes (three major tsunamis) in the seventeenth century BC and two well-documented events, respectively, in 365 BC and 1303 AD [3], causing the loss and destruction of most of the cultural features of the coastal areas, and the death of hundreds of thousands of people [38]. Accordingly, tsunamis are considered one of the natural hazards that lead to the erosion and inundation of coastal shores, which threatens the protection of coastal communities, economies, and ecosystems [4]. In 2004,

Southeast Asia was hit by a devastating tsunami, which hit the coasts of 14 countries bordering the Indian Ocean, causing many human, urban, and economic losses. Due to its proximity to the area of seismic and volcanic activity, Indonesia had the biggest share of human and material losses. One of the shocking facts is that the Indonesian government was informed shortly before the accident of what was coming toward the shores of Sumatra by tsunami warning centers, but its decision did not support the idea of warning and did not predict the big losses [5]. This made the world pay attention to this devastating disaster and how dangerous it is to the survival and sustainability of coastal urban communities all over the world, especially if those communities have a high population density. Subsequently, this required the urgent need to study and analyze the risks of the tsunami, set plans for people's evacuation, and raise community awareness toward this disaster [5].

After the "Indonesian tsunami" disaster in 2004, UNESCO established intergovernmental coordination of the tsunami early warning system as well as a tsunami's impact mitigation system in both the northeastern Atlantic and the Mediterranean (known as NEAMTWS), which is responsible for monitoring any risks related to the tsunami. Egypt is a participating country in the United Nations Program and is aware of the potential exposure of its coastal communities to its dangers, but Egypt does not benefit from UNESCO awareness plans to develop and manage plans for tsunami risks on its coastal communities, raise awareness of the extent of its dangers, and study evacuation and escape methods. Egypt's case is similar to the Indonesian case, as the governmental institutions did not respond to threats that tsunami posed to the country [6]. UNESCO [4] clarified that 10% of marine earthquakes in the Mediterranean region, besides its geological condition and tectonic characteristics, increased the chances of causing tsunami waves toward the northern coasts of Egypt at any moment [7]. Many scientific research and historical documentation confirm the probability of having a Mediterranean catastrophic tsunami every 140 years [5].

1.2. Research Goal

The research aims to provide a planning framework that governs and directs the planning process in an integrated manner, starting from the regional level to the local level for areas exposed to the tsunami risk, in order to eliminate the potential problem of the plan focusing on one stage and ignoring others, or focusing on a sectoral dimension and ignoring the rest of the sectors or dimensions.

1.3. Research Problem

Many studies and research are interested in finding the proper procedures and solutions to face the potential tsunami risks of some coastal regions. But these solutions or procedures are not presented in an integrated manner that achieves comprehensive planning and takes into account the specificity of the region and the reflection of its nature on the planning of the local communities that are at risk of a tsunami. Alexandria as a city and region is not far from the same problem where all futuristic plans and strategies lack the integrated planning framework that would have strengthened the efficiency of their application.

1.4. Research Importance

The tsunami disaster has become one of the most important challenges facing the northern coasts of Egypt, especially Alexandria (the overpopulated city), in the near future. It is therefore necessary to increase the institutional awareness of the seriousness of the destructive effects of the tsunami disaster and the implementation of strategic plans and early warning systems for the Mediterranean at several levels (globally, regionally, and locally) [30]. The awareness of coastal communities and their abilities need to raise in order to face these types of risks and mitigate their destructive effects. As a result, an integrated planning framework within urban development plans at the regional and local levels must be proposed as a research gap that must be addressed immediately, particularly in coastal developing countries that are in grave risk.

It will help in managing urban communities especially, in coastal areas by providing a scientific methodology as a tool in the short and long term to support the authorities and government agencies to deal with the disaster by taking the necessary measures to be ready for the development of plans and projects according to their inclusion for current and future sustainability of coastal communities.

The Egyptian government is shifting gradually from post-crisis management to pre-crisis management. In the case of potential tsunami damage, the different governmental authorities will need all scientific planning methodologies to help in applying the new perspective and insure the full shift to a natural disaster management approach.

1.5. Research Methods

The research paper depends on the historical approach to review the studies and research papers focusing on the tsunami risk and how to confront it. The deductive method is used to extract the main shortcomings in the various studies and to infer the integrated planning framework for areas facing tsunamis. To add objectivity to the proposed planning framework, the interview technique is used to get the suggestions and feedback of urban planning experts to improve the integration between the local and regional level and to improve the scientific value of the framework.

2. Why Alexandria

Alexandria is Egypt's second-largest city and major

seaport, with a population of 5.5 million people according to the 2021 national census predication and land area of over 230,000 acres. It has a semi-arid Mediterranean climate with mild, variable rainy winters and scorching, dry summers. It is located along the Mediterranean Sea coast in the north-central part of the country. The city is constructed on a narrow and somewhat elevated coastal ridge that faces the sea, and it has historically grown in a linear way with very high densities along its water's edge [3]. It has historical, touristic, and industrial importance, as it also includes 40% of the national industries and 50% of the petroleum industries [9]. Alexandria is considered as a metropolitan city as it is divided into six main districts (EL Montazah, East District, El Gomrok, Middle District, West District, Hay El Amereya) extending 32 km along the Mediterranean coast [2] (see figure 1), with the unsustainable urban expansion of the city, and urban expansion, especially in the coastal areas, is a new factor that increases the city's vulnerability to face future risks and disasters, as 35% of the recent population live within slums that can weak the resistance abilities of the natural factors [4]. The city includes many historical sites and a variety of economic activities, which confirms the need of preparedness to confront the risk of tsunami, so strategic urban plans must be drawn up at the regional and local levels to avoid human, economic, and urban losses.

2.1. Alexandria is Threatened by a Tsunami

By reviewing scientific studies on several tsunami scenarios that could affect Alexandria's coastlines, and according to historical events or when it comes to the geographical regions that affect them, the majority of them show the extent of destruction and catastrophic damage to the city in the event of its exposure to the tsunami waves. Hamouda et al., [10] assumed a possible scenario for tsunami waves on the coast of Alexandria based on the hypothesis of simulating the tsunami of 1303 and its origin being the Hellenic arc. It will take 35 to 45 minutes for the devastating waves to arrive. Alexandria and the western Egyptian coast, have a maximum-predicted wave height of 9 meters and a minimum wave height of 2 meters.

Figure 1. The Alexandria City Main Districts [5]

El-Sayed et al., [1] studied the possibility of Alexandria being exposed to a tsunami wave height between 0.5 m and 5.8 m, while Hamouda et al., [10] assumed a maximum tsunami wave height of 9 m, and based on these two studies in order, Eckert et al., [2] identified medium and worst scenarios. The worst scenario is a tsunami wave height of 9 m, while the medium is expected to be 5 m. This is the first research attempting to assess tsunami vulnerability and risk in Alexandria by applying remote sensing in the GIS software. The degree of vulnerability of the building in this study is categorized into five categories, ranging from very low to very high risk. As for the 5m scenario in the Gomrok district, about 12% of the buildings are exposed to a high degree of risk, while the Montazah district has a low degree of risk. As for the 9 m scenario, most urban areas in the Gomrok district (56%) and the Montazah district (60%) are at risk of a tsunami, which is the worst scenario.

El-Barmelgy [5] conducted a comparative analytical study for three scenarios for the city of Alexandria 5, 9, and 20 m as specified by Hamouda et al., [10]; Alvarez-Gomez et al., [11]; Eckert et al., [2] and Lovholt et al., [12]. This study used a model for assessing tsunami risks using GIS and was based on the levels of hazard risk conducted by Eckert et al., [2]. In the 5m scenario, 52% of the city's buildings are exposed to a severe degree of danger, while in the 9 m scenario, about 54% of the city's buildings are exposed to a severe degree of danger, and in the worst scenario, 20m, about 81% of the city's buildings are at high risk. These findings are utilized to forecast the number of human casualties based on the very high level of threat to the buildings in the following order, as well as the three scenarios for Alexandria. The number of victims is as follows: 379 thousand cases, 433 thousand cases, and 457 thousand cases.

In 2015, Pagnoni et al., [13] conducted numerical simulations to assess the city of Alexandria in terms of the damage caused by the tsunami by analyzing the worst-case scenario of the main seismic events originated by the eastern Hellenic Arc (EHA) with a maximum wave height of 4 m to determine the potential buildings lesion and residents. A damage assessment model has been applied by the EU-FP6 project SCHEMA using a building damage matrix and water inundation depth. The southwest of Alexandria is most affected by the tsunami, and about 13,400 buildings and 165,000 residents are at risk, which is equivalent to 3.2% of the total population of Alexandria city. The tsunami waves may inundate about 15 km^2 of the city.

El-Barmelgy and Hamed [6] refined the "Strategic Tsunami Risk Assessment and Planning Model" (STRAPM) and applied it to the city of Alexandria, where it proved that this tool allowed coastal communities to identify areas and buildings at risk to the danger of tsunami waves and thus helped to initiate evacuation plans. For scenario 3 m, the number of human losses was 418 thousand people, representing 7.7% of the city's population, the scenario 5 m recorded the number of losses of 1.8 million people, representing 32.7% of the city's population, and scenario 9 m recorded 2.5 million people or 45.8% of the city's population, and finally, the 20 m scenario recorded 3.2 million people, representing 59.5% of the city's population. The estimated number of victims indicates the catastrophic situation facing the city of Alexandria.

El-Hattab et al., [14] presented an assessment of tsunami risks that the city of Alexandria is exposed to by applying remote sensing and GIS using three possible scenarios of 5, 9, and 20 m, where he added some parameters to help in the evaluation process and then excluded the worst scenario (20 m). The results indicated in the 5 and 9 m scenarios are in the following order: the largest part of the city is exposed to risks of a very high degree (49.16% and 58.71%), followed by high risks (30% and 28.41%), and medium risks. Low and very low risks are (13.61% and 7.76%) and (20.82% and 12.88%), and the study notes that the city is at high risk unless measures such as the establishment of an early warning system in the Mediterranean are implemented.

Hassan et al., [15] presented an assessment of the tsunami risks to the city of Alexandria based on the worst-case scenario for the main seismic source, the East Hellenic Arc (EHA), with a wave height ranging between 5.5 - 6 m and a tsunami wave arrival expected time ranging between 45 and 50 minutes. The inundation map of the city and buildings' use classification conclude that more than 800,000 people are exposed to water inundation in the event of a tsunami, representing 15.8% of the population of Alexandria, which indicates the need to take appropriate measures to reduce this disaster.

All scientific research has shown that tsunami waves may cause great damage to the city of Alexandria. This is in addition to the historical events that confirm the exposure of Alexandria to the tsunami, which is a danger not to be underestimated with severe weakness of the city's coasts due to urban sprawl and the increase in population density on its shores. It is necessary for the institutions and authorities concerned with the development and planning of the Egyptian coasts (at the regional and local levels) to improve knowledge about tsunami risks and provide an integrated planning framework that highlights an integrated planning process aiming at sustaining the future of these areas and helps their resilience against the tsunami disaster.

3. Tsunami Studies Lack to the Integrated Planning Framework

Many studies dealt with frameworks or methods for dealing with tsunami-affected coastal communities, which were submitted by governmental institutions, specialized agencies, and stakeholders in order to take the necessary precautions to mitigate risks, but none of them provided an integrated planning framework to deal with tsunami risks

in the short and long term. For example, Stewart et al., [16] presented a guideline for planning land uses for coastal areas and took into consideration marine ecosystems and engineering frameworks for coastal structures. Scheer et al., [17] produced a model for the escape and evacuation plans from areas prone to tsunami risks. Moe and Pathranarakul [18] highlighted the existence of five stages for managing natural disasters during different periods, including pre-disaster, during the disaster, and post-disaster, which were then developed by Mojtahedi and Oo [19] who focused on the last stage of each, which was the stage of recovery. Gemaila [7] also reviewed the policies used in the strategy of planning and managing crises in coastal areas, but did not produce a planning framework, but merely recommendations that must be taken into account when preparing for coastal communities.

Through the reference studies, the lack of a complete and comprehensive framework was noted especially for the planning of urban communities in coastal areas prone to tsunami risks, which started from the regional level to the local level to help decision-makers and governmental organizations with scientific methods to deal with the disaster in all its stages. But it remains to review the planning studies at the regional and local levels for the city of Alexandria to see how they deal with potential tsunami threats and whether they produce an integrated planning framework to deal with these areas or not.

4. Did the Alexandria Region's and City's Plans Take Tsunami Hazards into Consideration as Part of an Integrated Planning Framework?

In this part, all regional and urban plans for the Alexandria region and city will be reviewed and will show how studies assess tsunami threats and their reflection on urban development plans by reducing the damage vulnerability. Land-use planning should increase the ability to resist natural disasters and urban planning should facilitate adaptation to tsunami risks, whether in existing urban areas or new urban expansions. Firstly, it’s important to know that the Alexandria region is one of Egypt's seven planning regions. Three governorates make up this region, and two governorates (Alexandria, Matrouh) are located on the Mediterranean Sea and both have coastal formations. GOPP is in charge to prepare urban master plans and supervise the Physical Planning Center for Alexandria Region [20].

4.1. Developmental Triangle Alexandria/Wadi Al-Natroun/El-Alamein till 2017

In addition to the creation of a new free trade zone and several industrial zones in the study region, the new international coastline road is being built [21]. Furthermore, study targeted the development of the coastal areas to take advantage of its ingredients to maximize the benefits as a priority, but conversely the environmental study and its recommendation mentioned no single information about the threat of tsunami at least for targeted coastal zones. Also, the strategy emphasized the significance of diversifying the economy by including knowledge-based activities like R&D centers, green technological industrial parks, and technological manufacturing, which need huge investments and need a study of risk assessment to avoid the loss of those capitals in the future.

4.2. Regional Development Strategy of the Alexandria Planning Region till 2022

The strategy targeted the year 2022 to be accomplished, and the set objectives were very interested to take advantage of the Alexandria region's special and distinctive location, to increase its worldwide competitiveness and attract more foreign and local investments and international trade. The region's free industrial zones are revitalizing to provide more support and consolidation for the region's exports through upgrading main seaports [22]. Despite these objectives, the study did not take into consideration the threats of the tsunami and never found out any particular studies for this purpose.

4.3. Integrated vision for the development of Alexandria Governorate until 2050

The vision links the main urban core in the region, which is the city of Alexandria and its western extensions, including the existing urban sites west and southwest of Alexandria, in the form of urban nuclei that gradually expand to accommodate the expected modified population, who will increase by 4 million people as additional residents as a result of the population growth. This is in addition to propose a new industrial zone in the far south of the city as an industrial community with integrated services which is environmentally compatible and can provide more job opportunities [23]. But the environmental studies focus on the issue of shore erosion and the places that need to be protected according to shoreline studies, and do not focus on other risks such as tsunami or flooding.

4.4. Developmental Strategy for Alexandria Governorate till 2022

This study dealt with the Alexandria governorate as a direct spatial level, which means clear impacts of environmental impacts on the study area. Furthermore, by looking to dimensions and strategic principles of the strategy it relied on the restriction of further industrial expansion in Alexandria's existing metropolitan area, as well as the designation of new industrial zones and destinations in the new towns then limiting future spontaneous urban growth and the formation of new slums, as well as upgrading and rehabilitating those that already existed [24]. The new locations either for industries or

towns should be chosen depending on specific environmental studies considering all available risks and directing those locations away from them and the priority for inhabitants or industries, which will be determined to shift should be given for high-risk areas or unsafe industrial or populated zones, and certainly, this aspect had been missed totally in the particular planning study.

4.5. The Strategic Plan for the Alexandria Region 2030

The plan indicated the need for environmental conservation to deal with the coastal environment as an environment of high sensitivity and fragility that required the expansion of coastal protection projects, preserving dunes, organizing coastal groundwater extraction operations, and taking the required measures to protect coastal areas, especially urban ones, from the dangers of rising sea levels and their potential effects on urbanization and agricultural productivity [25]. As seen the plan mentioning the multiple risks that might face the city region of Alexandria, however, the environmental study process did not clarify the specific studies, which needed to build a vision about such risks.

4.6. Alexandria Strategic Urban Plan 2032 – ASUP 2032

GOPP [26] assigned the preparation of ASUP 2032 to an International Agency for Planning consultation in January 2012 to acquire international expertise of preparing plans and strengthen the process of participation in preparing development plans and setting priorities. ASUP 2032 reviewed the environmental issues, including the natural environmental risks of the tsunami and the extent of its destruction in case it occurred, and worked to establish adequate protection systems such as breakwater on the shore and early warning systems in the Mediterranean Sea. ASUP 2032 depended on the results of Jelínek et al., [27] to determine the levels of risk for only two districts of a total of six, but this did not reflect on the futuristic urban plan, which included urban expansions beside multi development projects.

4.7. Integrated Coastal Zone Management in the Northern Coat of Egypt (ICZM) 2017

The Integrated Coastal Management of the Egyptian Northern Coast aims to prepare an integrated plan for development on the Egyptian northern coasts overlooking the Mediterranean in cooperation with NWRC, funded by the Ministry of Water Resources and Irrigation and UNDP, to form a comprehensive and integrated understanding of the most important challenges facing coast sustainability [28,8]. The study divided the Egyptian north coast into a group of units according to their natural characteristics. The most important challenges and threats to the coastal unit CU07 were identified for the city of Alexandria, including the effects of climatic changes, the high level of flooding, and the level of erosion along with the city. The study recommended an evaluation of the non-climate threats that could be exposed, such as tsunamis, but the recommendations were not taken into consideration within the study process and methodology.

4.8. The Urban Development Strategy for the Egyptian Coastal Facades (Northwest Coast of the Mediterranean)

GOPP [29] was assigned to prepare the urban development strategy for the Egyptian coastal facades (Alexandria sector) in a way to create a development vision for sustainable development, taking into consideration the current situation of coastal problems, issues, and requirements. The study reviewed previous development and sectoral plans approved by the concerned development authorities on Egyptian coasts. The determinants of development had been set for risky areas resulting from climatic changes and rising sea levels and the extent of their direct impact on coastal development. The study reported that the city of Alexandria was one of the most dangerous areas according to many risks such as erosion and floods, but the study did not mention tsunami potential threats within the proposed projects to protect the city's shores.

4.9. Shortcomings of Incorporating Tsunami Hazards in the Urban Plans

By reviewing the regional strategies and urban plans of Alexandria, the shortcomings of incorporating tsunami risks into the current planning methodology have been noticed. This is largely related to currently insufficient data to devise a proper plan in addition to the limited knowledge of tsunami risks among institutional bodies and decision-makers. It is also related to the lack of participation and interconnection between researchers and government agencies in an attempt to provide authorities and decision-makers with the scientific methods of how to reduce its severity, to preserve human lives and the local and regional economy. As all the research reviewed in this paper confirms, there is an extremely high probability of facing tsunami, but all urban strategies and plans ignore the phenomenon of the tsunami and do not consider it into their schemes. This research work supports the region and the city planning authorities concerned with Alexandria with the integrated planning framework to include it in the strategies, plans, and future development projects.

5. Proposed Integrated Planning Framework

5.1. The Way to Build the Framework

Any planning framework should achieve sustainability

in the city and its region [31], so a comprehensive framework should be integrated starting from the regional level to the local level. The regional level is very important to be addressed in any studies for tsunami hazard as the large cities and small village communities frequently have different vulnerabilities as a result of a variety of factors, the most important of which is the quality of building and infrastructure construction. Not only can formal legal and regulatory environments differing between regions and districts, but also can informal traditions, which are frequently influenced by local disaster histories [37].

At the same time the regional aspect was limited in most studies, as the local level was the main area of interest for most cases. A few works focused on the phenomena of tsunamis at the regional level, such as the World Bank [18], which tried to illustrate the different scenarios at the regional level for the tsunami incidence and the influence on the local urban bodies and their vulnerability, and it was a guide to put a hand on the stage of vulnerability and the stage of the regional area background data collection. The link between the regional and local levels, especially at the stage of planning, was not clear, as it mostly gave the advantage to the local level to set the planning procedures and precautions. Two main approaches documented in case of dealing with the devastating effects of natural disasters are: the first is a proactive approach, where plans are prepared for preventive measures to be implemented to mitigate the effects of the disaster; the second is a reactive approach, which is the response in the application of plans developed in the previous phase and post-disaster recovery. Many previous studies tried to draw intellectual methodology within the proactive and reactive approach, for example the study of Moe and Pathranarakul [18] classified natural disaster management (NDM) into five stages: prediction, warning, emergency relief, rehabilitation, and reconstruction. The main activities in (NDM) can be divided into four main activities: mitigation, preparedness (pre-disaster), response (during a disaster), and recovery (post-disaster). The proposed framework extracts the previous different stages, by rearranging them in different ways, and some modified stages have to be added to build an integrated framework.

Accordingly, the proposed framework is divided into three main phases named, the pre-disaster, the disaster, and the post-disaster phase (see figure 2). The three phases including seven targeted main processes can be defined as vulnerability, assessment, planning, coping, mitigation, response, and recovery [32]. The main process is illustrated into eight stages to build the framework, four at the regional level and four at the local level and all stages will cover all disaster response time as before, during and after the disaster.

The first stage (collecting background research and regional information) could be considered as a preparatory step to find out all details and information to build risk knowledge. Theoretical tsunami hazard characteristics or effects should be reviewed and learned from Region Historical Background or tsunami's Events. The governance aspect will be considered as all key persons should be known, such as regional organizations (Stakeholders, Political and decision-makers), which are involved in urban and strategic planning (see figure 3).

The second stage (designing the operational risk maps): as mentioned before, this stage seeks to find out the vulnerability level at the regional level through communication with the National/International Observation and Modeling Network to produce ground instability and seismicity forecast maps. The previous step will help in determining the geometrical and mechanical properties of the surface layers, which in turn will draw landslide maps and improve cartography of tsunami risk. It is very important to improve institutional coordination and communities should engage in diverse and environmentally sustainable livelihoods resistant to hazards [33]. All outputs should be performed in a complete transparency partnership with important local stakeholders, particularly elected officials (see figure 3).

The third stage (estimating tsunami damage): risk determination is the target of this stage, which helps to cope with tsunami risks. By using a qualitative method to define the potential areas that might be affected by tsunami inundation areas and regional land use, it will be easier to assess the highly vulnerable areas to define the regional cluster (exposed and safe areas). The production of tsunami hazard mapping catalog and evacuation route maps is necessary to prepare self-protection and fast impact maps (see figure 3).

The fourth stage (setting up a tsunami hazard mitigation plan): giving proper command is the target of any planning process, and this will be done by classifying areas regarding possible protection. Areas under different levels of risk will have development projects according to possible protection. Finally, a link should be created between the region and the city's future vision and development projections, with consideration to all previous aspects.

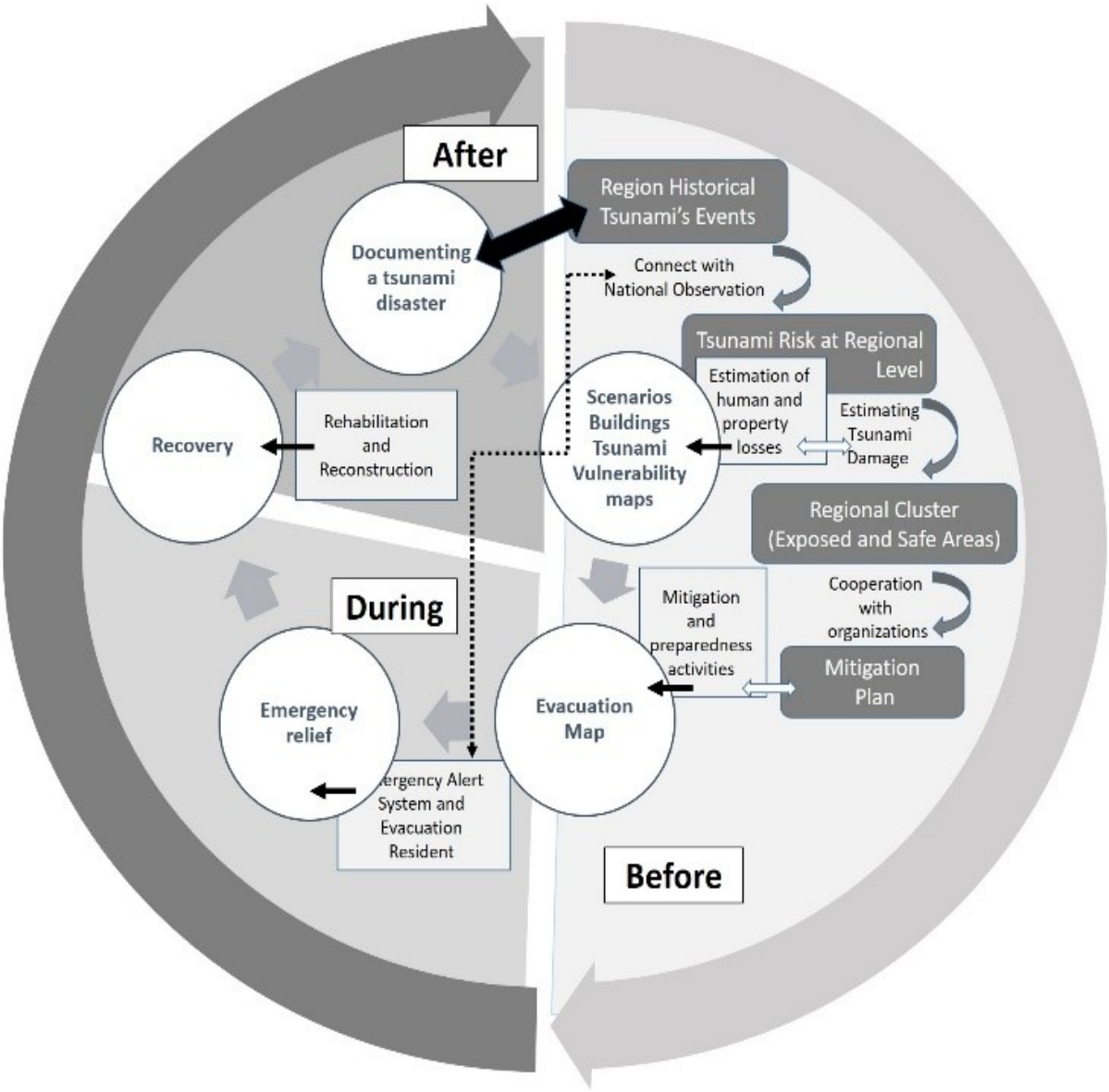
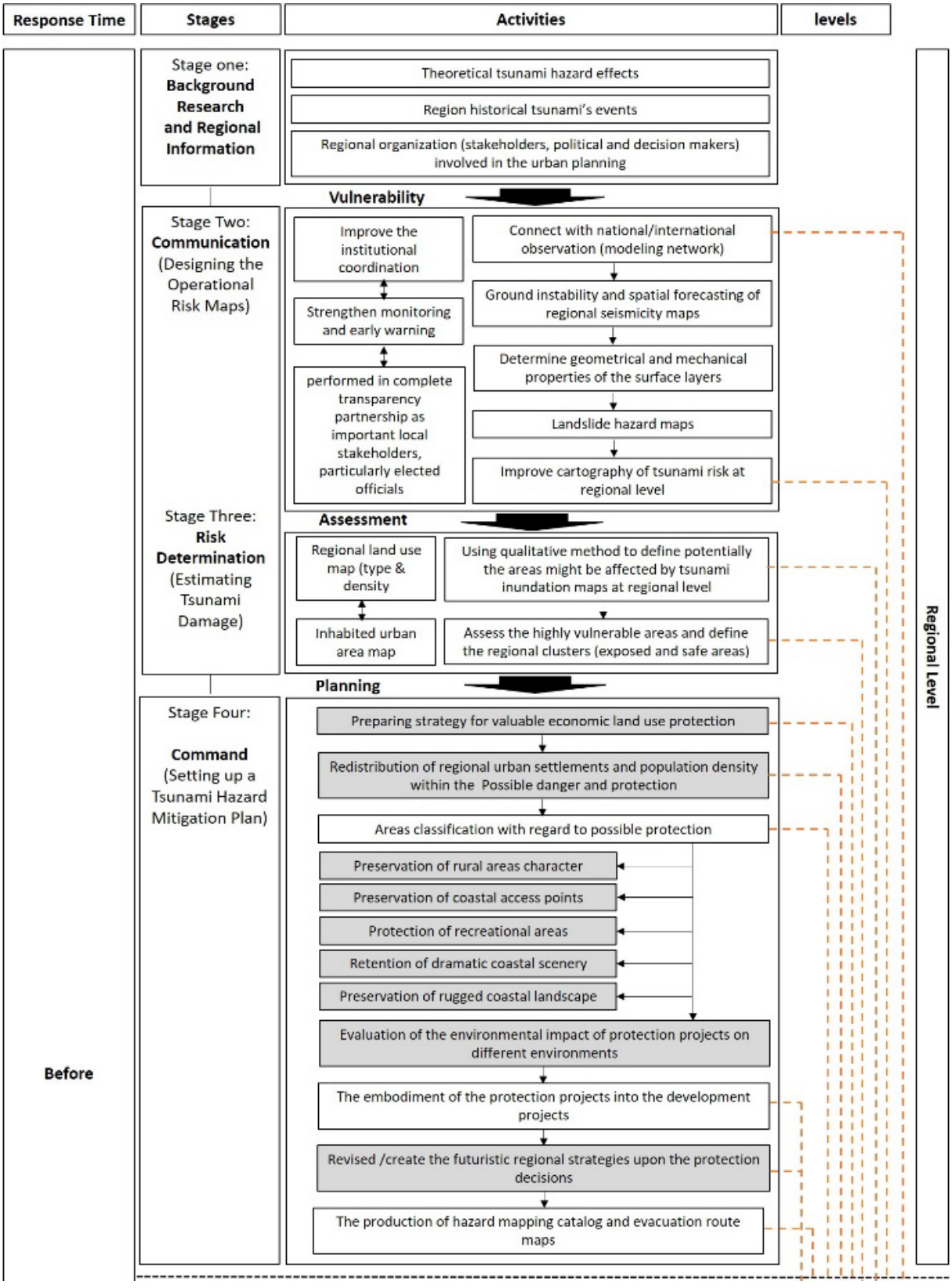


Figure 2. Different Time Processes for the integrated Planning Framework (by Authors)


Response Time
Stages
Activities
levels
Before
Stage one: Background Research and Regional Information
Theoretical tsunami hazard effects
Region historical tsunami's events
Regional organization (stakeholders, political and decision makers) involved in the urban planning
Vulnerability
Stage Two: Communication (Designing the Operational Risk Maps)
Improve the institutional coordination
Strengthen monitoring and early warning
performed in complete transparency partnership as important local stakeholders, particularly elected officials
Connect with national/international observation (modeling network)
Ground instability and spatial forecasting of regional seismicity maps
Determine geometrical and mechanical properties of the surface layers
Landslide hazard maps
Improve cartography of tsunami risk at regional level
Assessment
Stage Three: Risk Determination (Estimating Tsunami Damage)
Regional land use map (type & density
Inhabited urban area map
Using qualitative method to define potentially the areas might be affected by tsunami inundation maps at regional level
Assess the highly vulnerable areas and define the regional clusters (exposed and safe areas)
Planning
Stage Four: Command (Setting up a Tsunami Hazard Mitigation Plan)
Preparing strategy for valuable economic land use protection
Redistribution of regional urban settlements and population density within the Possible danger and protection
Areas classification with regard to possible protection
Preservation of rural areas character
Preservation of coastal access points
Protection of recreational areas
Retention of dramatic coastal scenery
Preservation of rugged coastal landscape
Evaluation of the environmental impact of protection projects on different environments
The embodiment of the protection projects into the development projects
Revised /create the futuristic regional strategies upon the protection decisions
The production of hazard mapping catalog and evacuation route maps
Regional Level

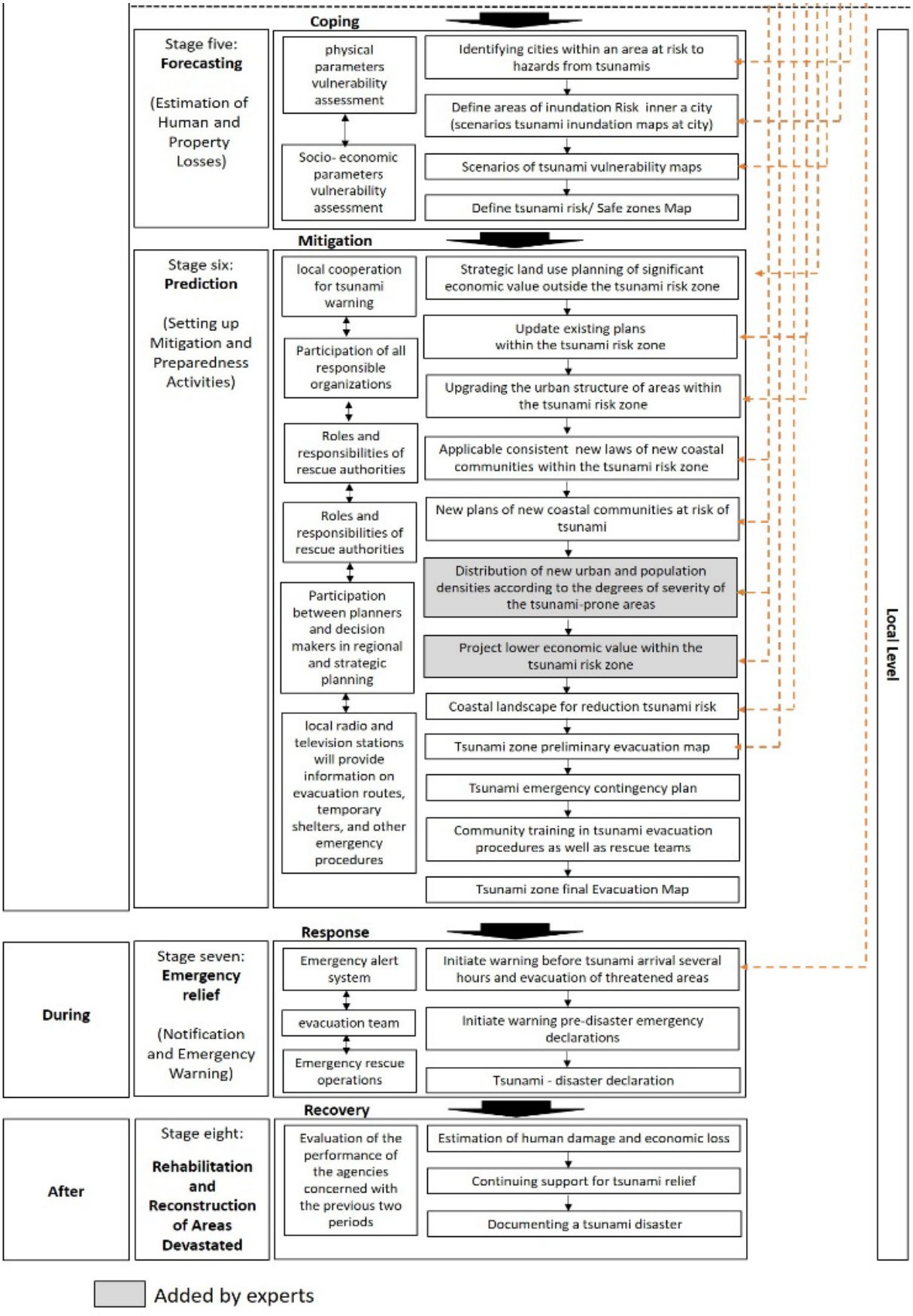


Figure 3. The Proposed Integrated Planning Framework (By Authors)

At the local level, the framework is divided into three basic phases: the pre-disaster, the phase of the disaster, and the post-disaster phase, and the first two phases depend largely on the information supply from the regional level. The coping and mitigation stages represent the pre-disaster phase at the local level, while the response stage represents the disaster phase, and the final stage of recovery represents the post-disaster phase (see figure 3).

The fifth stage (estimation of human and property losses) monitoring different scenarios for the city's water inundation levels will be built by using inundation maps at the regional level and by using the identification of safety and risk areas at the regional level, which will help in preparing possible scenarios to assess the extent to which buildings are affected by the tsunami (urban-social-economic) at the local level. A map of dangerous areas and safety zones within the city will also be identified at this stage (see figure 3).

The sixth stage (setting up mitigation and preparedness activities) involves the participation of the bodies responsible for preparing protection at the regional and local levels, which comes through several tasks, including preparing a strategic plan to transfer valuable land uses outside the disaster-prone areas (see figure 3), such as hospitals, NGOs, industrial areas, civil defense stations, and emergency and rescue team camps. in addition to high-economic-value land uses that cannot be compensated in the short term, such as public transportation, railways, large-scale educational and commercial services, and dangerous uses such as nuclear reactors and power plants [7]. The urban structure should be upgraded in disaster-prone areas [16]. With the support of the regional level output maps, it is possible to identify areas that can be protected, especially those facing the shorelines of tsunami risk areas exposed to natural buffers (areas of agriculture and tree gardens) [36], and link urban development projects at the regional level by updating coastal communities' urban plans that are exposed to tsunami risks and includes them in development projects that suit the specifics of their conditions and innovating modern building methods that can cope with a tsunami [16]. Evacuation maps at the regional level should also be used as guiding maps to prepare a preliminary evacuation map at the local level to serve the necessary evacuation process for the population. It is a basic tool used by the affected population to save their lives and help them escape to the nearest safe locations [17]. Then, it is extremely necessary to prepare emergency plans for the population within the disaster-prone areas through training rescue teams and prepare networks for local communication for early warning and communication between groups at risk to distribute their roles and responsibilities [34], and the necessary societal arrangements should be made to carry out the evacuation process by preparing escape maps in the form of booklets to be distributed to the population, then preparing public seminars and highlighting the role of the media in educating the population through various means of communication to arrive at a final escape map after evaluating the exercises and identifying areas of weakness to improve them [7].

The seventh stage (notification and warning in an emergency) is the stage of the actual confrontation of the disaster and is related to the speed of its control by the concerned agencies of the country (see figure 3). It is carried out through a set of the following alerting actions using the warning networks at the regional level [35,7]:

- Warning and alerting work before the disaster occurs at a time that allows the support and guidance team to implement the evacuation procedures for the affected population according to the previously announced plans,
- Warning and alert work immediately before the disaster, allowing the implementation of emergency procedures, rescue operations, and temporary accommodation,
- Declaring the disaster's occurrence to halt the drain of resources and reduce the magnitude of future losses.

The eighth stage (rehabilitation and reconstruction of areas devastated) is the stage where the plan to confront the disaster and contain the effects is completed (see figure 3), and it is carried out through a set of tasks as follows [34,7]:

- Compiling a list of all human and material losses,
- Maintaining support operations for shelter centers,
- The return of residents to their homes following the removal of destruction debris or the transfer of residents to temporary housing,
- Rehabilitating psychologically afflicted people,
- Appropriate restitution for property damage,
- Evaluating the performance of relevant authorities in order to improve confrontation methods and plans,
- Documenting and recording the disaster as learning process to gain experience in dealing with such occurrences.

5.2. The Framework Amendment

The proposed framework is presented in front of twelve experts in the area of urban and regional planning; some of them are interested in climate change studies and its reflections on the field of planning. After presenting the framework and furnishing all the important information, the study goal and problem, the interview depends on two main questions. The first question was about expert opinion, and the second was about any suggestions to enhance the scientific value of the framework. 83% of them saw the proposed framework as very integrated and comprehensive, and no additional points needed to be added. 18% of opinions had different suggestions, mainly in the stage of planning, and they asked to make this stage more detailed and systematic. Some of the suggested steps, such as protecting valuable economic land use at the regional and local levels, as well as identifying and preserving distinctive features for each area and unit, were

listed below. Some of them showed concern with the legislation and executive process, but they pointed out that it should be the concern of new research in the future.

5.3. The Benefits of Integration at Regional and Local Levels in Facing Tsunami Threats

A. The integration between the regional and local levels will achieve many procedural benefits, like:

- high level of coordination between the various institutes operating within the same territory,
- Managing the requirements and demands of various regions within the same country,
- Decreeing the overlapping between the multiple studies at the same level,

B. The integration between the regional and local levels will achieve many physical benefits, like:

- Protecting valuable land because it will be defined by regional characteristics and checked at the local level,
- Choosing precise locations for national defense away from any tsunami threats,
- Perfect suggestions for the new urban and rural communities' locations respecting evacuation routes and risky zones,
- Creating continuous monitoring for communities in medium and less risky zones,
- Finding the best evacuation routes away from special economic and ecosystem areas.

5.4. How to Ensure the Successful Integration between Regional and Local Level in Facing Tsunami Threats

- Establishing regional planning authorities in the different regions to support the local municipalities with the recommended strategies,
- Starting communication with the national intuitions involved in global studies about tsunamis,
- Don't give accreditation for any city or village's plan without taking into account the regional studies and their recommendations, especially in threatened areas,
- Regional strategies should be updated every five years at the most, especially in risky areas, and the results should be directly reflected in the plans of cities and villages.
- Taking into consideration the new research in the area of tsunamis and supporting the regional authorities with expert specialists to develop the technical team,
- Always maintaining the link between environmental, economic, social, and urban plans, as well as discussing potential threats and their implications.

6. Discussion

The proposed framework will direct the governments with all different authorities to apply successfully the needed actions before, during and after tsunami disaster. But there are intellectual and methodological changes which are needed to successful implementation of the proposed framework, see (table 1).

Table 1. Intellectual and methodological needed changes (By Authors)

Before	After
The government is responsible for emergency management	The government is responsible for mobilizing national resources, after a disaster event
Reliance on local responders and volunteers only	Reliance on stakeholders, local responders and volunteers
The reactive approach	The proactive approach as government primarily responsible for disaster management and first response operations
Depending on "culture of apathy"	Depending on "culture of preparedness"
Focusing on urban planning	Involve disaster and emergency management into urban planning
Post-event planning activities	pre-event planning activities
Hard measures such as "sea walls"	Soft measures such as "community drills and escape plans"
Normal building strategy	"Build Back Better" strategy

According to table 1, the changes revolve around the three main pillars. There is the change of urban planning process by involving disaster and emergency management into urban planning, the change of hard measures like sea walls which is still valid in some areas to the soft measures such as preparing evacuation plans, and lastly the change of the government dogma against the emergency management. The three types of changes are needed and will be illustrated in the next lines.

6.1. Planning Change

The area of planning needs to be changed through two main steps; the first is by shifting from the post-event planning activities to pre-event planning activities and the second is involving disaster and emergency management into urban planning. The two-transformation process can be illustrated as next [37,38]:

- City's districts have aimed at modifying their spatial planning by adopting the concept of tsunami risk reduction. The concept includes tsunami risk zonation, control of land/building permits in high-risk zones, and control of population density,

- Providing more tsunami escape buildings and conducting more regular tsunami drills. One of the ways is to include annual tsunami drills at the city/town level as part of the obligatory district regulations,
- Seismic building retrofits should be standard, state-of-the-art shock-absorbing foundations for high-rise towers (using seismic base isolation technology) should be routine, and these initiatives are no way to be complemented by public education campaigns and technologically advanced warning systems,
- Vulnerable structures should be determined by retrofitting programs,
- Emergency shelters, should be planned with adequate space and privacy, and little with stock of women's sanitary supplies, and continence aids for the elderly,
- Infrastructure construction of special defenses such as sea walls,
- Establishment of Online disaster risk maps (Disaster Risk Information System/DRMiS),
- The use of technology for disasters, including hundreds of electronic sensors placed around the (both on land and on the seabed) observation systems, urban and regional vulnerability analysis and hazard mapping, together with real-time warning systems that sound alarms to warn people of imminent approaching dangers,
- Strengthening spatial-based disaster risk management by revising spatial planning of cities/districts,
- Preplanning land use and urban planning, which will facilitate the adaptation of urban communities to the tsunami and its likelihood of occurring within 30 years,
- Relying on short-term plans and a degree of flexibility in cases of changes in the current situation and future scenarios,
- Studying the characteristics of the urban environment and seeing how fragile it is affected by the tsunami.

6.2. The Soft Measures (Evacuation Plans)

After the failure of hard measures like sea walls as the main protection against tsunami waves, changes have happened towards the soft measures, which depend on community drills and escape plans. Community drills could be developed through different agencies, whether governmental or NGOs.

The evacuation plans depend mainly on planning evacuation routes, which are an effective way to evacuate the residents affected by the possible risk of a tsunami to the nearest safe field in the least time in the easiest way to protect human lives. It is required to conduct a tsunami evacuation simulation system to study the relationship between the spatial characteristics of the evacuation routes and the capabilities of the evacuees to evaluate the behavior and methods of evacuation and identify related problems that support tsunami disaster prevention community planning and development with the participation of residents, and it increases dramatically with the effective communication of tsunami warnings to the public [39].

Evacuation models can be classified under 'dynamic' and 'static' approaches, and the most used 'static' models are least-cost-distance (LCD) approaches implemented geographic information systems (GIS) to an optimal path selection approach to improve upon route selection based only on the shortest path via measuring the paths with the shortest travel times (from every endangered location) to safety sites [40]. It depends on current evacuation conditions considering different scenarios and urban fabric.

Several parameters are considered as follows [39,37]:

- Identifying land cover maps and safe zones to allow for evacuation planning,
- Evacuation direction,
- Travel distance (vertical& horizontal evacuation),
- The distance between the risk zone to the nearest vertical evacuation facilities such as (tsunami evacuation buildings and tsunami evacuation towers) outside the inundation zone,
- Height and capacity of the tsunami evacuation facility,
- Destinations for horizontal evacuation,
- Destination for the nearest shelter,
- Preparing coastal communities on a routine basis to evacuate independently to higher ground, or to vertical evacuation structures, as soon as a tsunami occurs,
- Identifying safe refuge locations,
- Choosing the evacuation center's location precisely to reach from high access points,
- Tsunami evacuation signboards placed in the risky locations.

The dynamic approach uses an evacuation behavior model that identifies tsunami evacuation destination and time according to several human behaviors such as (population characteristics -population distributions – density population in risk area- level of education- different walking speeds and barrier-free evacuation routes for the elderly and handicapped), and the aim of this study is mitigation that would promote urban resilience [40].

6.3. Government Perspective Transformation

Governments are responsible for enforcing various efforts to protect cities at risk of tsunami through emergency management, but this role has recently become insufficient as the government has become responsible for mobilizing national resources following a disaster event. This transformation helps to shift from the reactive

approach to the proactive approach as the government is primarily responsible for disaster management and first response operations. For a successful full transformation, the following procedures need to be applied at two levels:

A. Government Level

- National governments are in charge of disaster management, which includes emergency rescue and relief operations as well as hazard mitigation,
- The ability to create institutions that have the technological capability to forecast disasters, as well as enforce land use and building regulations,
- National governments should have little autonomy, relying heavily on disaster legislation, financial resources, and protocols established by central ministries,
- Governments should prepare local municipalities for the possibility of a tsunami, and what scenario planning has been implemented to understand the magnitude of the tsunami risk and the likely damage to coastal communities,
- The government should put in place a national disaster management system,
- Taking advantage of global experiences in the development of coastal communities vulnerable to tsunami attacks 'international gold standard' in disaster planning like Japanese case,
- Including areas exposed to natural hazards within the priorities of the national development strategy, and defining intervention mechanisms in a specific and accurate manner, to become binding on all development decisions related to regional, structural, local, and detailed plans,
- Developing a set of binding standards for sustainable urban design in an effort to develop coastal communities.

B. Municipality Level

- Local municipalities are responsible for emergency response, and mitigation strategies are usually implemented by higher-level authorities due to the large budgets that are required as well as stringent land use and construction regulations,
- Strengthening local disaster management agency through regulations, budgeting, and staff training. Enacting a number of local bylaws related to disaster management,
- Composing a tsunami contingency plan and stimulating involving related stakeholders,
- Providing basic community services (health, education, and civic services) through a number of activities/training sessions for government officials, health workers, and teachers. The activities should also be accompanied by increasing the participating individuals on tsunami awareness,
- Establishing and defining binding controls for all parties involved (local government, citizens, investors, etc.) in the development process in general, and in areas prone to natural hazards in particular,
- Expansion of awareness and guidance programs for citizens and authorities concerned with the issue of the destructive effects of natural hazards on development, through the development of media,
- Creating coordination between the various efforts to recover from the crisis between the various organizations, through the establishment of a unit specialized in this at the time of crisis,
- Extensive community engagement and public education programs, comprising drills for students from kindergarten to university in exposed areas.

7. Conclusions

This paper aimed to find an integrated planning framework for cities facing the risk of tsunami as there was a research gap, especially in the integration between the regional and local planning levels. According to a literature scan, Alexandria, the second-most important city located on the north coast, faces the risk of tsunamis. The different plans that targeted the city and its region's future missed many studies and aspects to find a proper way to face the tsunami risk.

The proposed framework was induced using the qualitative method and the historical approach. Twelve experts edited the proposed framework to improve the scientific value added and increase its objectivity. 83% of them saw the proposed framework as very integrated and comprehensive, and no additional points needed to be added. 17% of opinions had different suggestions, mainly in the stage of planning, and they asked to make this stage more detailed and systematic.

Intellectual and methodological changes are needed to ensure successful implementation of the framework, and those changes revolve around three main pillars. The first is about the area of planning, the second is about the shifting to the sift measures from the hard measures, and the third is about the role of the government and its efforts to face the different challenges, and all required actions are given for each pillar to cover the area of this gap in the literature.

Acronyms and Abbreviations

Acronyms and Abbreviations (UNDP) United Nations Development Program, (GOPP) General Organization for Physical Planning, (NWSC) National Water Research Center, (UNESCO) The United Nations Educational, Scientific and Cultural Organization, (NEAMTWS) North-East Atlantic and Mediterranean Tsunami Warning System, (NWRC) The National Water Research Center.

REFERENCES

[1] El-Sayed, F. Romanelli, and G. Panza. Recent seismicity and realistic waveforms modeling to reduce the ambiguities about the 1303 seismic activity in Egypt, Journal of Tectonophysics, vol. 328, no. 3–4, pp. 341–357, Dec. 2000, doi: 10.1016/S0040-1951(00)00172-4.

[2] S. Eckert, R. Jelinek, G. Zeug, and E. Krausmann. Remote sensing-based assessment of tsunami vulnerability and risk in Alexandria, Journal of Applied Geography, vol. 32, no. 2, pp. 714–723, 2012, doi: 10.1016/j.apgeog.2011.08.003.

[3] The world bank. Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa Phase 1: Risk Assessment for the Present Situation and Horizon 2030 – Alexandria Area, (Issue January), 2011.

[4] UNESCO-IOC. Reducing and managing the risk of tsunamis, Vol. 57, Issue 57, 2011.

[5] El-barmelgy, Hesham Mohamed. Strategic tsunami hazard analysis and risk assessment planning model: A case study for the city of Alexandria, Egypt. International Journal of Development and Sustainability, vol. 3, no. 4, pp. 784–809, 2014.

[6] El-barmelgy, Hesham Mohamed, & Hamed, M. S. Tsunami risk assessment a mitigation planning tool. International Journal of Development and Sustainability, vol. 6, no. 9, pp.1048–1065, 2017.

[7] Shady Mohamed Gemaila. The impact of urban form facing tsunami risks (An application study on escaping plans), Cairo university- Faculty of Urban and Regional Planning, 2018. (In Arabic).

[8] Shaw, B., Ambraseys, N. N., England, P. C., Floyd, M. A., Gorman, G. J., Higham, T. F. G., Jackson, J. A., Nocquet, J. M., Pain, C. C., & Piggott, M. D. Eastern Mediterranean tectonics and tsunami hazard inferred from the AD 365 earthquake. Nature Geoscience, vol. 1, no. 4, pp. 268–276, 2008, https://doi.org/10.1038/ngeo151

[9] Frihy, O. E., Dewidar, K. M., & El Raey, M. M. Evaluation of coastal problems at Alexandria, Egypt. Ocean and Coastal Management, vol. 30, no, 2–3, pp. 281–295, 1996, https://doi.org/10.1016/0964-5691(95)00066-6

[10] Hamouda, A. Z. Numerical computations of 1303 tsunamigenic propagation towards Alexandria, Egyptian Coast. Journal of African Earth Sciences, vol. 44, no. 1, pp. 37–44, 2006, https://doi.org/10.1016/j.jafrearsci.2005.11.005

[11] J. A. Álvarez-Gómez, Í. Aniel-Quiroga, M. González, M. Olabarrieta, and E. Carreño. Scenarios for earthquake-generated tsunamis on a complex tectonic area of diffuse deformation and low velocity: The Alboran Sea, Western Mediterranean, Journal of Marine Geology, vol. 284, no. 1–4, pp. 55–73, 2011, doi: 10.1016/j.margeo.2011.03.008.

[12] F. Løvholt, S. Glimsdal, C. B. Harbitz, N. Zamora, F. Nadim, P. Peduzzi, H. Dao, and H. Smebye. Tsunami hazard and exposure on the global scale, Journal of Earth-Science Reviews, vol. 110, no. 1–4, pp. 58–73, 2012, doi: 10.1016/j.earscirev.2011.10.002.

[13] G. Pagnoni, A. Armigliato, and S. Tinti. Scenario-based assessment of buildings' damage and population exposure due to earthquake-induced tsunamis for the town of Alexandria, Egypt, Journal of Natural Hazards and Earth System Sciences, vol. 15, no. 12, pp. 2669–2695, 2015, doi: 10.5194/nhess-15-2669-2015.

[14] M. M. El-Hattab, S. A. Mohamed, and M. El Raey. Potential tsunami risk assessment to the city of Alexandria, Egypt, Journal of Environmental Monitoring and Assessment, vol. 190, no. 9, 2018, doi: 10.1007/s10661-018-6876-z.

[15] H. M. Hassan, C. Frischknecht, M. N. ElGabry, H. Hussein, and M. ElWazir. Tsunami hazard and risk assessment for Alexandria (Egypt) based on the maximum credible earthquake, Journal of African Earth Sciences, vol. 162, 2020, doi: 10.1016/j.jafrearsci.2019.103735.

[16] P. L. Stewart, R. J. Rutherford, H. a Levy, J. M. Jackson, and P. O. Box. A Guide to Land Use Planning in Coastal Areas of the Maritime Provinces, Fisheries and Oceans, Canada, No. 2443, 2003.

[17] S. Scheer, A. Gardi, R. Guillande, G. Eftichidis, V. Varela, B. de Vanssay, and L. C. Justin. Handbook of tsunami evacuation planning: SCHEMA (Scenarios for Hazard-induced Emergencies Management), project n°030963, specific targeted research project, space priority, Publications Office, Italy, 2011, https://doi.org/10.2788/34292

[18] T. L. Moe and P. Pathranarakul. An integrated approach to natural disaster management: Public project management and its critical success factors, Journal of Disaster Prevention and Management, vol. 15, no. 3, pp. 396–413, 2006, doi: 10.1108/09653560610669882.

[19] S. M. H. Mojtahedi and B. L. Oo. Possibility of applying lean in postdisaster reconstruction: An evaluation study, IGLC 2012 - 20th, Conference of the International Group for Lean Construction, 2012.

[20] The world bank. Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa Phase 2: Adaptation and Resilience Action Plan – Alexandria Area, Egypt, 2011.

[21] General Organization for Physical Planning. Developmental Triangle Alexandria/Wadi Al-Natroun/El-Alamein till 2017, Cairo, 1999. (In Arabic).

[22] General Organization for Physical Planning. The Regional Development Strategy of Alexandria Planning Region till 2022, Cairo, 2007. (In Arabic).

[23] General Organization for Physical Planning. Integrated vision for the development of Alexandria Governorate until 2050, Cairo, 2007. (In Arabic).

[24] General Organization for Physical Planning. Developmental Strategy for Alexandria Governorate till 2022, Cairo, 2008. (In Arabic).

[25] General Organization for Physical Planning. The strategic plan for the Alexandria region 2030, Cairo, 2018. (In Arabic).

[26] General Organization for Physical Planning. Alexandria Strategic Urban Plan 2032 – ASUP 2032, Cairo, 2012.

[27] R. Jelínek, S. Eckert, G. Zeug, and E. Krausmann. Tsunami

Vulnerability and Risk Analysis Applied to the City of Alexandria, Egypt, European Commission-Joint Research Center-Scientific and Technical Reports, Italy, 2009.

[28] Cantabria. Integrated Coastal Zone Management in the Northern Coat of Egypt (ICZM), Vol. 1, Egypt, 2017.

[29] General Organization for Physical Planning. The urban development strategy for the Egyptian coastal facades (Northwest Coast of the Mediterranean), Egypt, 2017. Online Available: http://gopp.gov.eg/wp-content/uploads/2020/07/الساحل-الشمالى-الغربى.pdf. (In Arabic).

[30] E. Boschi, S. Tinti, A. Armigliato, L. Graziani, and A. Manucci. A tsunami warning system for the Mediterranean: an utopia that could be implemented in a short time, Journal of Geophysical Research Abstracts, Vol.7, 2005.

[31] Seddeek, M. A. Towards Sustainable City-region in Developing Countries, International Research Journal of Social Science, Vol. 5, no. 10, pp. 52-60, 2016, Retrieved from http://www.isca.in/IJSS/Archive/v5/i10/9.ISCA-IRJSS-2016-149.pdf

[32] Dominey-Howes, D., & Goff, J. Tsunami Risk Management in Pacific Island Countries and Territories (PICTs): Some Issues, Challenges and Ways Forward. In Pure and Applied Geophysics, Vol. 170, no. 9–10, pp. 1397–1413, 2013, https://doi.org/10.1007/s00024-012-0490-8

[33] US IOTWS. How Resilient is Your Coastal Community? A guide for evaluating coastal community resilience to tsunamis and other hazards, United States Agency for International Development and partners, Bangkok, Thailand, 2007. Online Available: http://nctr.pmel.noaa.gov/education/IOTWS/program_reports/CoastalCommunityResilienceGuide.pdf.

[34] S. B. D. Communities. Building Tsunami-proof Communities – Showing How Tohoku Reconstruction Makes Use of Nature – Science Council of Japan Committee on Supporting Reconstruction after the Great East Japan Earthquake, Tokyo, pp. 63–100, 2012.

[35] Office of Emergency Services. Local Planning Guidance on Tsunami Response: A Supplement to the Emergency Planning Guidance for Local Governments, Second Edition, California Agencies, California,2000.

[36] K. J. Abhas, W. T. Miner, and S. G. Zuzana, Building Urban Resilience: Principles, Tools, and Practice, The World Bank, Washington, D.C., 2013, https://doi.org/10.1596/978-0-8213-8865-5

[37] Edgington, D. W. Planning for Earthquakes and Tsunamis: Lessons from Japan for British Columbia, Canada, Progress in Planning, October, pp. 100626, 2021, https://doi.org/10.1016/j.progress.2021.100626

[38] Syamsidik, Oktari, R. S., Nugroho, A., Fahmi, M., Suppasri, A., Munadi, K., & Amra, R. Fifteen years of the 2004 Indian Ocean Tsunami in Aceh-Indonesia: Mitigation, preparedness and challenges for a long-term disaster recovery process, *International Journal of Disaster Risk Reduction*, Vol. *54*(January), pp. 102052. 2021, https://doi.org/10.1016/j.ijdrr.2021.102052

[39] T. Yamada, N. Yamasaki. Simulation of tsunami evacuation behavior considering inland direction. International Journal of Disaster Risk Reduction, Vol. 65, pp. 102566, 2021, https://doi.org/10.1016/j.ijdrr.2021.102566

[40] J. Qüense, C. Martínez, J. León, R. Aránguiz, S. Inzunza, N. Guerrero, A. Chamorro, M.Bonet. Land cover and potential for tsunami evacuation in rapidly growing urban areas. The case of Boca Sur (San Pedro de la Paz, Chile), International Journal of Disaster Risk Reduction, Vol. 69, pp. 2022, 2021, https://doi.org/10.1016/j.ijdrr.2021.102747