Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa

Phase 2 : Adaptation and Resilience Action Plan – Alexandria Area

Final Version

25 May 2011

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<th>AASTMT / Egis BCEOM International / IAU-IDF / BRGM</th>
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<td>S. Rouhana</td>
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<td>25 May 2011</td>
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<tr>
<td>A. Tiwari</td>
<td>The World Bank</td>
<td>25 May 2011</td>
</tr>
<tr>
<td>T. Abou Gharara</td>
<td>AASTMT</td>
<td>25 May 2011</td>
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## History of modifications

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World Bank Department and Unit in Charge:
Middle East and North Africa Region, Sustainable Development Department
Urban and Social Development Unit

Co-financiers:
Global Facility for Disaster Risk Reduction and Recovery (GFDRR)
Norwegian Trust Fund for Private Sector and Infrastructure (NTF-PSI)
Trust Fund for Environmentally and Socially Sustainable Development (TFESSD)

Project team:
Anthony G. Bigio (Task Team Leader)
Tim Carrington
Stéphane Hallegatte
Osama Hamad
Salim Rouhana
Asmita Tiwari

Peer Reviewers:
The team has benefited from the comments and advice of a number of peer reviewers in the course of the study, including Alex Bakalian, Henrike Brecht, Philippe Huc, Francis Ghesquière, Isabelle Forge, Jaafar Friaa, Alex Kremer, Michel Matera and Edward Tschan.

Consultants:
Egis Bceom International in consortium with IAU-IDF and BRGM
Yves Ennesser (Egis BCEOM International)
Victor Said (IAU-IDF)
Monique Terrier (BRGM)

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with the contribution of Abdalah Mokssit and Fatima Driouech from Maroc Météo
Partner of the World Bank for the study of Alexandria
   Arab Academy of Science, Technology and Maritime Transport

Partner of the World Bank for studying land subsidence phenomena
   European Space Agency

Partner of the World Bank for dissemination
   Marseille Center for Mediterranean Integration (CMI)

Partners in Egypt
Institutional Coordination
   National level
      Egyptian Environmental Affairs Agency (Coastal Zone Management Department)
   Alexandria
      Alexandria Governorate

Other Stakeholders
- Cabinet Information and Decision Support Center
- Coastal Research Institute
- Alexandria Holding Company for Drinking Water and Sanitation
- Ministry of Housing Utilities and Urban Development (General Organization for Physical Planning)
- Physical Planning Centre for Alexandria Region
- United Nations - International Strategy for Disaster Reduction
- RCDRR - Regional Center for Disaster Risk Reduction
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Acronyms and Abbreviations

AAC  Annual Average Cost
AASTMT  Arab Academy for Science, Technology and Maritime Transport
ASDCO  Alexandria Sanitary Drainage Company
AWCO  Alexandria Water Company
BaU  Business as Usual
B/C  Benefit/Cost ratio
BRGM  Bureau de Recherche Géologique et Minière
CBF  Cost-Benefit Analysis
CC  Climate Change
CPA  Civil Protection Administration
DEM  Digital Elevation Model
DGA  Design Ground Acceleration
EBI  Egis BCEOM International
EEAA  Egyptian Environmental Affairs Agency
EGP  Egyptian Pound ($kEGP = 10^3 EGP; MEGP = 10^6 EGP$)
EMA  Egyptian Meteorological Authority
EMS98  European Macroseismic Scale 1998
ENSN  Egyptian National Seismic Network
ERC/IFRC  Egyptian Red Crescent / International Federation of Red Cross
ESA  European Space Agency
GDP  Gross Domestic Product
GEF  Global Environmental Facility
GEV  Generalized Extreme Value
GFDRR  Global Facility for Disaster Reduction and Recovery
GHG  Green House Gases
GIS  Geographical Information System
GNP  Gross National Product
GOPP  General Organization for Physical Planning
IAU-IDF  Institut d’Aménagement et d’Urbanisme d’Ile de France
IDSC  Information and Decision Support Centre
IPCC  Intergovernmental Panel on Climate Change
LAT  Lowest Astronomical Tide
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<tr>
<td>Ms</td>
<td>surface-wave magnitude</td>
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<td>MSK</td>
<td>Medvedev-Sponheuer-Karnik seismic scale</td>
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<td>Mean Sea Level</td>
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<td>NAARS</td>
<td>National Authority for Remote Sensing and Space Sciences</td>
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<td>NCCMDRR</td>
<td>National Committee for Crisis Management and Disaster Risk Reduction</td>
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<td>National Centers for Environmental Prediction</td>
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<td>NGO</td>
<td>Non Governmental Organization</td>
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<td>NIMS</td>
<td>National Information Management System</td>
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<td>Persistent Scatterer Interferometry</td>
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<td>WasteWater Treatment Plant</td>
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Chapter 1 – Executive Summary

Background

Throughout the official development assistance of the World Bank to the Governments of the MENA region, a study on climate change adaptation and natural disaster preparedness in the coastal cities of North Africa has been launched in 2008, financed by the World Bank and by the fiduciary funds NTF-PSI, TFESSD and GFDRR managed by the World Bank.

This study focuses on three North African coastal cities: Alexandria in Egypt, Tunis in Tunisia and Casablanca in Morocco, and on the Bouregreg Valley between Rabat and Sale in Morocco, where a major urban development project is being planned and implemented.

In this context, The World Bank and the Arab Academy for Science, Technology and Maritime Transport (AASTMT) agreed on establishing a partnership for conducting the study on “Climate Change Adaptation and Natural Disaster Preparedness in Greater Alexandria”, to be part of the abovementioned regional study. The World Bank has dedicated to this study the international expertise of the consortium members that include IAU-IDF and BRGM led by Egis BCEOM International.

The present report deals with the Greater Alexandria region. Following the diagnosis produced during the first phase of the study, the purpose here is to develop an adaptation and resilience action plan for natural disasters and climate change.

Various threats and vulnerabilities

The first phase report included a comprehensive analysis of the different natural and socio-economic systems and characteristics of Alexandria. It covered risk assessment in the current situation and in 2030. A list of new vulnerabilities was also identified and spatially allocated on a map. In summary, the first phase report pinpointed the following main issues that need priority actions and immediate interventions in order to increase the city preparedness towards possible climate change risks and disasters:

- With a population of about 4 million and an area of over 230,000 ha, Alexandria is Egypt’s second largest city and its largest seaport. The city is built on a narrow and partially elevated coastal ridge facing the sea and is exposed to marine submersion, coastal erosion, earthquake, flooding and water scarcity risks. Informal areas, which house one third of Alexandria’s total population, with deteriorating buildings and infrastructure in old and dense parts of the city, and fast urbanization of surrounding areas over reclaimed wetlands and other low-lying areas make the city particularly vulnerable to these risks.

- Compared to the current situation, disaster risks are expected to worsen by 2030 due to climate change, and continuing urban expansion in new sites exposed to natural hazards. The city may face higher marine submersion, coastal erosion and water scarcity risks, along with an increase in seismic, land subsidence, and flooding risks. Additionally, climate changes may negatively affect public health.
• While natural risks are growing, the institutional capacity in Alexandria to manage these risks and prepare communities for potential future disasters and climate change impact is limited. The current organizational set-up of the emergency response systems remain highly centralized with limited coordination between agencies horizontally and vertically down to the level of communities.

**Structured and operational recommendations …**

The structural and methodological frame of the present Phase 2 report has been developed to ensure a necessary consistency and continuity with the Phase 1 assessments, with the aim of providing operational recommendations to decision makers.

As a result, the recommendations have been prepared using a sheet format, each sheet containing the relevant information for the definition and implementation of the recommendations: sphere of intervention (strategy), aim, time period (operational horizon), related risks, description, constraints / difficulties, uncertainties, concerned authorities and sectors, monitoring and evaluation means, cost, scheduling, mapping. The sheets are complemented by an economic evaluation of the action plan and an institutional analysis.

The limits of the present approach must however be emphasized. These limits are directly related to limited knowledge of risks and vulnerabilities in the study area, and to the global and strategic method of addressing these issues within the framework of the present study. Therefore, the present study does not seek to be comprehensive nor immediately implement the action plan, but is rather aimed at providing the local authorities with the technical and economical background enabling them to incorporate the recommendations in the plans and programs currently being prepared or to be implemented. Hence, the actions sheets remain at a summary level of definition and will have to be complemented by detailed investigations that are not in the scope of the present study.

**… for an integrated and diversified action plan**

In response to the abovementioned threats and risks, the action plan is made of 27 recommendation sheets that are presented by risk category: seismic risk, erosion / marine submersion risk (storm surge and tsunami), flood risk, drought / water scarcity risk, and multiple risks.

Within each category, the sheets are classified according to their sphere of intervention:

- Recommendations concerning the institutional preparedness and emergency plans of the urban districts in view of climate change impacts and disaster risks;
- Recommendations for urban planning aimed at minimizing the vulnerabilities identified: specific recommendations in terms of land-use and urban planning that would facilitate the adaptation of the urban locations to the changing climate and increase their resilience to natural disasters. Such recommendations refer to the existing urban coverage and to the projected urban development until the 2030 scenario;
- Recommendations concerning the infrastructure assets and the physical investments that will be required to protect or upgrade the urban assets and systems in order to adapt: coastal marine defenses, key urban infrastructure hot-spots, water supply and drainage systems, buildings …
The first two spheres of intervention correspond to strategic axes, dealing with risks in a global and cross-disciplinary way. The third one refers to a more thematic and technical approach of risks and vulnerabilities. Moreover, the institutional area is more “preparedness” oriented, while urban planning is rather a “prevention” approach, the technical measures and physical investments being devoted to the “protection” of assets and populations.

The first priority actions, with respect to identified issues at stake and anticipated benefits, are mostly the domain of the institutional and urban planning spheres. Indeed, these actions cover the whole range of natural risks (synergized effects), are not expensive, are “no regret” actions (cost-effective even without climate changes), and are flexible / reversible.

Regarding the institutional and operational support, the Project highlights the importance of improving the coordination at the Ministerial and Governorate levels, establishing a monitoring and early warning system (both on local and national levels), improving preparation and self-protection of populations, and setting up emergency plans and public awareness campaigns. A monitoring and follow-up mechanism could be affiliated to the newly established urban observatory system in Egypt.

The urban planning measures include implementation of building and urban regulations that responds to the climate change risks, and the integration of climate change adaptation and mitigation measures within an urban management mechanism. In the field of urban (physical) interventions, it is proposed to undertake proactive measures towards the protection of urban zones prone to natural disasters both in Abu Quir and ElMax Areas. In new expansions, the implementation of a pilot project that demonstrates a risk-sensitive urban planning model has been suggested, and would be replicated in other areas. A comprehensive vulnerability assessment of the existing buildings in the city is also recommended.

In order to manage and monitor seismic and tsunami risks, the Project proposes actions regarding the development of microzoning activities in Alexandria, to be incorporated into urban development plans. It also proposes a better evaluation of national risks by improving knowledge of tsunamigenic sources (location, seismic nature, gravitation, size, probability of occurrence, etc.). The Project proposes several actions to control coastal erosion and marine submersion, by improving knowledge of the changes in coastal beaches and defining suitable erosion control intervention strategies. Additional actions target the prevention of sea submersion risks in different city zones, especially in the Abu Quir district. In the field of flood control and water resources management the proposed actions focus on controlling and optimizing water consumption, reusing treated wastewater, controlling runoff discharges in existing and new urban areas, and the cleaning and maintaining of combined sewage networks.

Based on the proposed actions, the local and national knowledge of and preparedness for natural disasters and climate change should be improved. Long term mitigation and protection measures could enhance the city’s future and the well-being of its inhabitants.

**A cost-effective action plan?**

The present report includes an economic valuation of the recommended remedial adaptation actions against the costs of the impact of climate change and natural disasters. However, due to the lack of data, the economic analysis focuses on three main topics: discounting, cumulative seismic damage and evaluation of the proposed adaptation option, and the cumulative damage of climate change on the health sector.
Discounting is a fundamental yet difficult part of the economic analysis, especially as far as general interest is concerned, over the considered time range. The framework developed is applied to earthquake adaptation and the cumulative damage to health by climate change. It allows refining the calculation of the cumulative damage of quantified disasters proposed in phase 1, ending up with a total amount of 18,000 M EGP or 20% of the current GDP of the city over a 40-year period for earthquake activity only.

The earthquake adaptation option proved not to be economically viable in the framework developed, mainly because the level of hazard is rather low. The cumulative damage to health slightly exceeds 3,000 M EGP over 40 years. However, the study scope does not encompass health adaptation options hence it is not possible to calculate direct benefits of dedicated health options.

It is somehow difficult to develop a point of view on the non-quantified assessment that encompasses all other hazards under consideration. It is tempting to extend or adapt what could be said with more certainty on the other sites of the study (Tunis and Casablanca). We shall however remain prudent in this attempt, since the results are built upon a baseline that is particular to each site. Still, without prejudging the results of more focused studies on Alexandria, we can set out some of the lessons learned that we think might be relevant to Alexandria as well. Indeed, when some adaptation options have shown a very high level of economic efficiency on the other two sites, it can be extrapolated that the result might also hold for the somewhat similar context of Alexandria.

In this context, it becomes apparent that early warning systems, including both ascending and descending alerts, are a very wise investment. This is easy to see: investment is relatively small, while potential benefit is huge (all disasters are concerned).

Also, the coastal investments proposed usually offer very high returns, even though they impact a somewhat smaller base. Coastal management in that sense also seems to be a “non-negotiable” investment that must be made.

As far as water management and flood management are concerned, results are less conclusive, and depend more on the site. And, on each site, there seems to be stronger variations in spatial distribution. Infrastructures are always expensive, but the base they impact is also huge. Whether benefits outstrip cost or not can hardly be guessed at in general terms, but require more dedicated and site-specific study.

An institutional framework for the implementation of the action plan

The different recommendations of the action plan are under the responsibility of the government services and state organisations identified on each sheet. To coordinate the initiative and monitor the implementation of the different actions, it would be desirable to nominate a coordinating body. This could be the Egyptian Environmental Affairs Agency (EEAA), because of its role which is both central and cross-disciplinary as far as questions of natural risk prevention are concerned. Also, questions of climate change and particularly adaptation are in a position to be handled by them. The EEAA will have to consult with the Ministries of Finance and Foreign Affairs in order to set out the financial arrangements for the project. It is, in fact, fairly unlikely that the Egyptian government will be able to finance all the actions out of its own funds, so some international aid will have to be requested. Multilateral development agencies and Egypt's main economic partners could be approached. As soon as possible, these partners will be approached for
launching and financing any additional studies required for the implementation of the action plan (drawing up the ToR, planning the consultations, selection and coordination of the consultants). The operations to be launched first are those defined above as a priority.

Around the EEAA, a coordination committee could be set up which brings together the financial partners and the main authorities concerned by the action plan: the Information and Decision Support Centre, the Civil Protection Administration, the General Organization for Physical Planning, the Alexandria Governorate, the Holding Company for Water and Wastewater, the Egyptian Meteorological Authority, and the Shoreline Protection Agency. Under the aegis of the EEAA, this coordination committee could meet every three months to review the progress of the action plan.
Résumé exécutif

Contexte

L’étude se concentre sur trois villes de première importance dans la région : Alexandrie en Égypte, Tunis en Tunisie, et Casablanca au Maroc. Le site du projet de développement urbain de la Vallée du Bouregreg au Maroc a également été inclus dans l’étude. Le choix de ces villes a été concerté avec les Autorités nationales responsables, qui ont exprimé un intérêt majeur pour l’étude.

Dans ce cadre, la Banque Mondiale et l’Académie Arabe de Science, Technologie et Transport Maritime (Arab Academy for Science, Technology and Maritime Transport – AASTMT) ont décidé de constituer un partenariat pour conduire l’étude sur la région d’Alexandrie. La Banque mondiale a confié la réalisation technique de l’étude au groupement conduit par Egis BCEOM International, avec IAU-IDF et le BRGM.

Le présent rapport concerne la région du Grand Alexandrie. Après l’élaboration d’un diagnostic lors d’une première phase d’étude, il s’agit ici de développer un plan de résilience et d’adaptation des villes au changement climatique et aux désastres naturels.

De nombreuses menaces et vulnérabilités
Le rapport de Phase 1 comprenait une analyse exhaustive des différentes caractéristiques naturelles et socio-économique d’Alexandrie. L’étude couvrait l’évaluation des risques en situation actuelle et à l’horizon 2030. Une liste de vulnérabilités a également été identifiée et localisée spatialement sur carte. En résumé, le rapport de Phase 1 soulignait les principaux problèmes suivants, qui nécessitent des actions prioritaires et des interventions immédiates dans le but d’améliorer l’état de préparation de la ville vis-à-vis des risques éventuels de changement climatique et de désastres naturels :

- Avec une population de 4 millions d’habitants et une superficie de plus de 230 000 ha, Alexandrie est la 2ème plus importante ville d’Egypte et son plus grand port maritime. La ville est construite sur une corniche étroite et de hauteur variable faisant face à la mer et exposée aux risques de submersion marine, d’érosion côtière, de séismes, d’inondations et de pénurie d’eau. L’urbanisation informelle qui abrite un tiers de la population totale d’Alexandrie dans les parties denses et âgées de la ville, présentant des constructions et des infrastructures dégradées, et l’urbanisation rapide des zones périphériques en lieu et place de zones basses et humides rendent la ville particulièrement vulnérable à ces risques.
Comparés à la situation actuelle, les risques de désastres devraient s’aggraver à l’horizon 2030 du fait du changement climatique et de l’expansion urbaine dans de nouvelles zones exposées aux aléas. La ville devrait faire face à des submersions marines, érosions côtières et pénuries d’eau plus importantes, ainsi qu’une augmentation des risques sismiques, d’inondations et de subsidence. De plus le changement climatique peut avoir un impact négatif sur la santé humaine.

Alors que les risques naturels augmentent, la capacité institutionnelle à gérer ces risques à Alexandrie et à préparer les communautés à des désastres potentiels futurs et aux impacts du changement climatique est limitée. La structure organisationnelle actuelle des systèmes de réponse reste hautement centralisée et présente une coordination limitée à la fois horizontalement entre agences et verticalement au niveau des communautés.

Des recommandations structurées et opérationnelles …

La structure du présent rapport et le cadre méthodologique mis en œuvre dans cette deuxième phase d’étude assurent une nécessaire cohérence et continuité avec l’évaluation menée en Phase 1, dans un souci constant d’opérationnalité pour les autorités concernées.

Ainsi, après un rappel des objectifs et axes d’intervention découlant de l’évaluation des risques et des vulnérabilités, les recommandations sont développées sous forme de fiches d’action, chaque fiche contenant l’ensemble des informations nécessaires à la définition et à la mise en œuvre de la recommandation : type de risque concerné, sphère d’intervention, objectif poursuivi, horizon opérationnel, descriptif, contraintes / difficultés, incertitudes, autorités et secteurs concernés, critères d’évaluation, coût, éléments de programmation. Les fiches sont en outre complétées par une évaluation économique du plan d’action et un cadrage institutionnel.

Notons toutefois que la démarche a des limites, découlant notamment du niveau de connaissance actuel des risques et vulnérabilités dans la zone d’étude, et du caractère global et stratégique de l’approche développée dans le cadre de la présente étude. Cette étude n’a donc pas la prétention d’être exhaustive et d’application immédiate, mais donne aux autorités locales les éléments techniques et économiques permettant d’inscrire les recommandations dans les plans et schémas directeurs en cours de préparation ou à venir. Les fiches d’actions restent ainsi à un niveau très synthétique et devront être complétées par des études de détail qui ne relèvent pas du champ de la présente étude.

… pour un plan d’action intégré et diversifié

Le plan d’action se compose de 27 fiches de recommandations présentées par type de risque : risques multiples, risque sismique, risque érosion / submersion marine (onde de tempête ou tsunami), risque inondation, risque sécheresse / ressource en eau.

A l’intérieur de chaque catégorie de risque, les fiches sont ensuite classées par sphère d’intervention :

- Les recommandations concernant la préparation institutionnelle et les plans de secours des quartiers urbains, sur les aspects changement climatique et risques naturels ;
• Les recommandations en planification urbaine, visant à réduire les vulnérabilités identifiées : recommandations spécifiques en termes d’utilisation des sols et d’urbanisme facilitant l’adaptation des sites urbains au changement climatique et augmentant leur résilience aux désastres naturels. De telles recommandations concernent aussi bien la situation urbaine actuelle que les développements urbains projetés jusqu’à l’horizon 2030 ;

• Les recommandations concernant les infrastructures et investissements physiques nécessaires à la protection et au renforcement des systèmes et patrimoines urbains : dispositifs de défense côtière, infrastructures clefs, systèmes d’adduction d’eau et de drainage, immeubles, …

Les deux premiers domaines d’intervention correspondent à des axes stratégiques, traitant les risques de façon plutôt globale et transversale. Le troisième relève d’une approche plus thématique et relativement technique des risques et vulnérabilités. Par ailleurs, le domaine institutionnel est surtout tourné vers la « préparation » au risque, alors que la planification urbaine correspond plutôt à une approche de « prévention », et que les mesures techniques et investissements visent essentiellement la « protection » des biens et des personnes.

Les actions jugées prioritaires au regard des enjeux identifiés et des bénéfices attendus relèvent essentiellement de la sphère institutionnelle et de la planification urbaine. En effet, ce sont des actions couvrant l’ensemble des risques (effets de synergie), à faible coût, de type « sans regret » (utiles même en l’absence de changement climatique), et réversibles.

En ce qui concerne le support institutionnel et opérationnel, le projet souligne l’importance d’améliorer la coordination, aussi bien au niveau ministériel et des gouvernorats, en établissant un système de suivi et d’alertes précoces (à la fois au niveau local et national), en améliorant la préparation et l’autoprotection des populations, et en mettant en place des plans de secours et des campagnes d’information et de sensibilisation du public. Un mécanisme de monitoring et de suivi pourrait être confié au dispositif d’observatoire urbain récemment mis en place en Egypte.


Dans le but de gérer et de suivre les risques sismiques et de tsunamis, le projet propose des actions de microzonage d’Alexandrie, à prendre en compte dans le développement urbain futur. Il propose également une meilleure évaluation des risques nationaux en approfondissant la connaissance des sources tsunamigénèques (localisation, nature sismique, gravitation, taille, probabilité d’occurrence, etc.). Le projet propose un certain nombre d’actions pour contrôler l’érosion côtière et la submersion marine en améliorant la connaissance sur l’évolution du littoral et en définissant des stratégies pertinentes de contrôle de l’érosion. D’autres actions visent la prévention des risques de submersion marine dans différentes zones de l’agglomération et plus particulièrement dans le district d’Abu Quir. En matière de contrôle des inondations et de
gestion des ressources en eau, les actions proposées se concentrent sur le contrôle et l'optimisation de la consommation en eau, la réutilisation des eaux usées, le contrôle des rejets pluviaux dans les zones urbaines actuelles et projetées, ainsi que le nettoyage et l'entretien des réseaux unitaires d’assainissement.

Sur la base des actions proposées, l'état de préparation local et national vis-à-vis des désastres naturels et du changement climatique devrait être amélioré. Des mesures d’atténuation et de protection sur le long terme pourraient renforcer le futur de l'agglomération et le bien être de ses habitants.

*Un plan d’action efficace ?*


L’actualisation est une composante fondamentale et cependant difficile de l’analyse économique, d’autant plus que l’intérêt général est concerné sur la période de temps considérée. Le cadre développé est appliqué à l’adaptation au séisme et aux dommages cumulés sur la santé liés au changement climatique. Il permet d’affiner le calcul de dommages cumulatifs des désastres quantifiés proposés en Phase 1 et aboutissant à un montant total de 18 milliards LE ou 20 % du PIB actuel de la ville sur une période de 40 ans pour le seul risque sismique.

L’option d’adaptation aux risques sismiques s’avère économiquement non viable dans le cadre de l’exercice, principalement à cause d’un niveau de risques relativement faible. Les dommages cumulés sur les conditions sanitaires dépassent légèrement 3 milliards LE sur une période de 40 ans. Cependant, le champ de l’étude ne couvre pas les options d’adaptation sur la santé, de fait, il n’est pas possible de calculer les bénéfices directs de ces options.

Il est difficile de se faire une opinion sur l’*évaluation non-quantitative* qui concerne tous les autres aléas considérés. Il est tentant d’étendre ou d’adapter les résultats obtenus avec plus de certitude sur les autres villes du projet (Tunis et Casablanca), nous devons cependant *rester prudents* sur cet essai, car les résultats sont obtenus sur des données de base qui sont propres à chaque site. Néanmoins, sans préjuger des résultats d’études plus détaillées sur Alexandrie, nous pouvons tirer quelques leçons que nous pensons également pertinentes pour Alexandrie. En effet, lorsque certaines options d’adaptation témoignent d’un très haut niveau d’efficacité économique sur les deux autres villes, on peut penser que ces résultats valent aussi pour le contexte d’Alexandrie, qui est relativement similaire.

Dans ce contexte, il apparaît que les systèmes d’alertes précoces, incluant à la fois les alertes montantes et descendantes, sont des *investissements très avisés*. Cela est facile à comprendre : l’investissement est relativement faible alors que le risque potentiel est énorme (tous les types de désastres sont concernés).

De même, les investissements côtiers proposés offrent habituellement d’importants retours sur investissement, même si leur champ d’impact est plus limité. A cet égard, les mesures de gestion côtière apparaissent également comme un investissement non négociable, devant être consenti.
En ce qui concerne la gestion des ressources en eau et des inondations, les résultats sont moins conclusifs et dépendent davantage du site considéré. Sur chaque site d’étude, des variations importantes dans la distribution spatiale apparaissent. Les infrastructures sont toujours onéreuses mais le champ d’impact est étendu. De façon générale, que les bénéfices soient plus importants que les coûts peut difficilement être deviné, mais nécessite des études dédiées et plus détaillées.

Une cadre institutionnel pour la mise en œuvre du plan d’action

Les différentes recommandations du plan d’action sont sous la responsabilité des services de l’État et organismes publics identifiés dans chaque fiche. Pour animer la démarche et suivre la mise en œuvre des différentes actions, il serait souhaitable de nommer une instance coordinatrice. Celle-ci pourrait être l’Agence Égyptienne des Affaires Environnementales (Egyptian Environmental Affairs Agency - EEAA), en raison de son rôle à la fois central et transversal sur les questions de la prévention des risques naturels. De plus, les questions de changement climatique, et notamment d’adaptation, ont vocation à être traitées par cette agence.

Autour de l’EEAA pourrait être constitué un comité de pilotage regroupant les partenaires financiers et les principales autorités concernées par le plan d’action : le Centre d’Information et de Support Décisionnel (Information and Decision Support Centre), l’Administration de la Protection Civile (Civil Protection Administration), l’Organisation Générale de la Planification Physique (General Organization for Physical Planning), le Gouvernorat d’Alexandrie, la Holding des Eaux et d’Assainissement (Holding Company for Water and Wastewater), l’Autorité Météorologique Égyptienne (Egyptian Meteorological Authority), et l’Agence de Protection du Littoral (Shoreline Protection Agency). Sous l’égide de l’EEAA, ce comité de pilotage pourrait se réunir tous les trois mois pour passer en revue l’état d’avancement du plan d’action.

1. Background

Throughout the official development assistance of the World Bank to the Governments of the MENA region, a study on climate change adaptation and natural disaster preparedness in the coastal cities of North Africa has been launched in 2008, financed by the World Bank and by the fiduciary funds NTF-PSI, TFESSD and GFDRR managed by the World Bank.

This study focuses on three North African coastal cities: Alexandria in Egypt, Tunis in Tunisia and Casablanca in Morocco and on the Bouregreg Valley between Rabat and Sale in Morocco, where a major urban development project is being planned and implemented.

In this context, The World Bank and the Arab Academy for Science, Technology and Maritime Transport (AASTMT) agreed on establishing a partnership for conducting the study on “Climate Change Adaptation and Natural Disaster Preparedness in Greater Alexandria”, to be part of the abovementioned regional study. The partnership has been established through Memorandum of Understanding (MoU) signed between the two parties in July 2009, by which the AASTMT agreed to provide in-kind contribution to finalize the study of Alexandria. Parallel to that, the World Bank has dedicated the international expertise of the consortium members that include IAU-IDF and BRGM led by Egis BCEOM International.

2. Reminder of the Study Objectives

The main objectives of the study are:

1. Assessing the climate change and natural disaster vulnerabilities of the four urban locations by the 2030 scenario. The main outputs consist of: a) providing updated and exhaustive scientific assessments of future climate change and sea-level rise, and probabilistic risk assessment of natural disasters; b) conducting an in-depth analysis of the geological, topographical, hydrological, and environmental nature of the four sites; c) assessing the current urban coverage and the vulnerability of the urban infrastructure assets present on the sites; d) projecting the growth of the urban agglomerations at the 2030 scenario based on the current demographic and urbanization trends; e) constructing multi-layered GIS urban vulnerability maps based on the previous tasks; f) evaluating the socio-economic costs of the impacts of climate change and natural disaster risks in the four urban locations; and g) assessing the roles and activities of national and local institutions in the urban planning, infrastructure provision and disaster preparedness relevant to the four urban locations.

2. Formulating action plans to improve their adaptation to climate change and preparedness to natural disasters. The main outputs will consist of: a) recommendations aiming at minimizing the vulnerabilities identified; b) recommendations concerning the infrastructure assets and the physical investments that will be required to protect or upgrade the urban assets and systems in order to adapt; c) recommendations concerning the institutional preparedness and emergency plans in view of the climate change impacts and disaster risks; recommendations concerning the public information, education and communication campaigns to be carried out at local level; and d) an economic valuation of the implementation of the
recommended adaptation actions against the costs of the impacts of climate change and natural disasters, if unchecked.

3. Disseminating the study results and engaging stakeholders in related decision-making: through: a) interaction with the national and local counterparts that have the responsibility for the management and development of the four urban locations; b) taking part in national and regional dissemination events organized by said counterparts, by the World Bank, with the collaboration of relevant agencies.

This report is considered the main outcome of the second phase for Greater Alexandria. The present action plan has been developed through participatory processes with the national and local stakeholders, who have provided their comments on the phase I report and in developing this action plan, in compliance with Phase 3 objectives. The proposed recommendations in this action plan are based on the comments received in the workshop held on 16-17 June 2010 in Alexandria, where government representatives and national stakeholders participated and gave their feedback and recommendations on the vulnerability assessment.

3. Content of the Present Report

The second study phase consists in the development of recommendations on adaptation to climate change and natural disasters. The present report is structured according to the following chapters:

Chapter 1 – Executive Summary
Chapter 2 – Introduction
Chapter 3 – Reminder of the Diagnosis
Chapter 4 – Objectives and Orientations
Chapter 5 – Action Sheets
Chapter 6 – Economic Analysis
Chapter 7 – Proposal for an Action Plan
Chapter 8 – Institutional Aspects

Through the presentation of the objectives and orientations of the adaptation and resilience plan, Chapter 4 forms a transition between the risks and vulnerabilities identified in Phase 1 (Chapter 3), and the Phase 2 recommendations, presented under a sheet (card) format in Chapter 5. An economic analysis is provided in Chapter 6. The recommendations are then aggregated and ranked in Chapter 7, according to their level of priority, cost and efficiency, in an action plan for the coming years. At last, general recommendations for strengthening the local capabilities with respect to the implementation of the action plan are given in Chapter 8.

As pointed out in Phase 1, the lack of reliable baseline data is a major drawback for the evaluation of risks and vulnerabilities. Thus, most of the recommendations presented hereafter call for the implementation of additional studies and surveys, likely to remove part of the uncertainties related to natural disasters and vulnerabilities in Alexandria. In this context, the proposed prevention or protection investments cannot be precisely defined. It is especially difficult to estimate investment costs, so most of the costs provided in the action sheets are given as an indication, or as an example. As it is impossible to aggregate these
costs, it is therefore not possible in the framework of the present study to estimate the total cost of the action plan and to compare it to the cost of climate change and natural disasters.

This report is the final version, dated 25th of May, 2011

It has been drafted by the consortium Egis BCEOM International / IAU-IDF / BRGM, in partnership with the Arab Academy for Science, Technology and Maritime Transport (AASTMT). The authors assume the full responsibility with regard to the content of the present report. The opinions here expressed within this report do not commit the World Bank to their execution or reflect the World Bank’s vision towards the phenomena of climate change in the Northern Coastal zone of Africa.

For more information about the context and purpose of the present project, please refer to the inception report. Furthermore, all baseline data on the analysis of risks and vulnerabilities are detailed in the Phase 1 report.
Chapter 3 – Reminder of the Diagnosis

The present chapter is aimed to recall the results of the Phase 1 study, i.e. the risks and vulnerabilities addressed through the present action plan.

Study Area

With a population of about 4 million and an area of over 230,000 ha, Alexandria is Egypt’s second largest city and its largest seaport. It is located along the coast of the Mediterranean Sea in the north central part of the country and has a semi-arid Mediterranean climate characterized by mild, variably rainy winters and hot, dry summers. The city is built on a narrow and partially elevated coastal ridge facing the sea and has historically expanded in a linear fashion with very high densities along its water-front.

Greater Alexandria currently spans over 230,000 ha with its 2006 population estimated at 4.3 million by the national census. The current boundaries of the urban agglomeration of Alexandria consist of seven districts, Al-Montazah, Shark (East), Wasat (Middle), Gharb (West), Al-Gomrok, Al-Agamy and Al Amreya, along with the Borg Al Arab city and three villages. Evolving from a small settlement built by Alexander the Great in the year 331 BC, the urban agglomeration has historically expanded in a linear fashion, and currently reaches from the coastal village of Abu Quir in the North-East to the village of El-Deir in the South-West. The city, which shows very high densities along its water-front, is built on a narrow and partially elevated coastal ridge facing the sea, behind which the lakes, low-lying rural areas, and wetlands are located.

The review of the geological and topographical context shows that Alexandria is built on a coastal plain. The area is characterized by irregular hills in the southern parts with an elevation from 0 to 40 meters above mean sea level and slopes towards the Mediterranean Sea northward. Areas below Mean Sea Level (MSL) are Abu Quir natural depression (former lagoon), Maryut lagoon south of Alexandria, and aquaculture ponds bordering the southern margins of the coastal lagoon. Large parts of the beach and coastal flats expand between zero and two meters above MSL. Areas above three and four meter lie within the coastal dunes at the backshore of Abu Quir bay and the southern part of the lower delta plain, about 35 km from the shoreline. In the framework of the present study, a digital elevation model (DEM) has been generated, using all available topographical data. Its precision is however insufficient to enable accurate erosion, flooding or submersion simulations.

Alexandria has a semi-arid Mediterranean subtropical climate characterized by mild, variably rainy winters and hot, dry summers. January and February are the coolest months with daily maximum temperatures typically ranging from 12°C to 18°C. July and August are the hottest months of the year with an average daily maximum temperature of 30°C. Alexandria experiences violent storms, rains (up to 100 mm/day), and sometimes hail during the cooler months. Meteorological data collected over the last 30 years show trends of increasing frequency of heat waves and precipitations, and decreasing frequency of cold waves. For the purpose of this study, the study area is defined by the perimeter of the available master plans of the Greater Alexandria.
A city threatened by various natural risks

Evaluation of natural hazards in the present situation highlights that Alexandria is at a ‘medium’ risk\(^1\) of marine submersion and coastal erosion, and a comparatively lower risk of earthquake, tsunami, flooding, and water scarcity. The city of Alexandria faces following hazard risk in the current situation:

Land Subsidence

Based on the study of radar satellite images\(^2\), Alexandria city is affected by terrain deformation such as subsidence\(^3\) and uplift. Land motion mapping over the entire city of Alexandria, which was supported by the European Space Agency (ESA), found that:

- Between 5 to 9% of the measured points correspond to negative movement or land subsidence. The natural (i.e. not tectonic) rate of subsidence is estimated to range from 0.04 cm/ year (based on ERS satellite images from 1992 to 2000) to 0.9 cm /year (based on ENVISAT images from 2003 to 2009). A rate of 0.6 cm/year was estimated based on ALOS images from 2007 to 2009.
- Less than 1.2% of the measured points show positive movements or uplift.
- The most affected areas within the Alexandria city are along the northern border of Lake Maryut, and in the southern part of the city between Gharb district and Abu Quir.

In the absence of in-depth ground based observations, the most probable explanation concerning the land subsidence in the study area remains the compressing of the recent deposits. Further studies will be necessary for a better understanding of all the deformation phenomena affecting the city of Alexandria and its surroundings.

Earthquake

Being close to two major fault zones in Egypt (Eastern-Mediterranean Cairo-Faiyoum and Suez- Cairo-Alexandria), Alexandria City has suffered significant damages due to earthquakes in the past. The city was shaken by five earthquakes in the last century, the most recent one being in 1998. Although details about the economical values of damages from past earthquakes are not known, it is

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\(^{1}\) It is important to note that the risk level presented in the report are developed as a rough and simplified measure to facilitate the comparison between the present situation and the 2030 situation, between the various hazards under consideration, and between the studied sites (4 urban areas distributed in 3 countries). This rating exercise includes some subjectivity and cannot reflect uncertainties regarding risk assessment. Therefore, it cannot be used (and/or correctly understood) outside the framework and context of the present study.

\(^{2}\) Within the framework of this study, the European Space Agency (ESA) supported land motion mapping over the whole city of Alexandria through the application of Interferometric Synthetic Aperture Radar (InSAR) technologies, using images from ALOS, ERS and ENVISAT satellites. ALTAMIRA Company carried out the study in 2009 by reconstituting monthly historical ground displacement for the urban and rural areas of Alexandria to measure and map the evolution of the actual urbanized coastline during the last two decades.

\(^{3}\) Subsidence is the motion of a surface (usually, the Earth's surface) as it shifts downward relative to a datum such as sea-level.
estimated that old, non-reinforced masonry or adobe buildings, and structurally weak reinforced concrete buildings suffered majority of damages. 

Probabilistic assessment of earthquake risk shows that the Alexandria urban area faces a moderate risk, corresponding to an intensity of around V-VI MSK for the 100-year return period and around VI MSK for a 475-year return period. The resulting potential damage from this level of earthquake risk can be very light to light (slight damage to a few poorly constructed buildings). However, given the poor geotechnical quality of Alexandria’s soils, an increased degree of intensity can be considered for some of the urban areas, with “moderate” potential damage (serious damage to older buildings, masonry collapse) for the least frequent events. Subsidence areas detected by satellite interferometry can be considered as sensitive to such “site effect”.

Tsunami

Currently, the risk of damage by tsunami is considered to be low in Alexandria, as these events have very long return periods in the city. Tsunami has a probability of 12% of occurrence in 100 years, 6% in 50 years, and around 2.5% in 20 years. The two known historic incidents of tsunamis in Alexandria occurred in the years 365 and 1303 AD, with reported wave heights of 1m and 2.9m respectively. Return period of a similar magnitude of tsunami event in Alexandria is estimated at 800 years.

Marine Submersion

The annually averaged variations of water level (tide-gauge records) measured at Alexandria Western Harbor from 1944 to 2006 (60 years) and the data measured at Abu Quir Harbor (1992 through 2005; 14 years) shows that the mean sea level at Alexandria, and Abu Quir has risen 1.8 and 3.4 mm/yr, respectively. Difference between the two measurements can be explained by local ground subsidence or uplift.

The coastal area is also subject to submersion risk, most evident during stormy periods. Storm surges in association with spring tides (high tides) raise water levels by 60cm above normal. Occasionally, high tides occur in combination with storm surges, and sea level can produce wave set-ups of 1.6 m. Such storm surges can submerge the shoreline but low lying areas expanding around Lake Maryut and South of Abu Quir are protected by natural ridges or sea walls.

Coastal Erosion

Based on the analysis carried out as a part of this study, the risk of coastal erosion hazard is ‘medium to high’ between the Dekhiela harbor and the Western port of Alexandria, as well as at the El Montazah, El Maamoura and Abu Quir beaches due to the absence of coastal protection devices along these beaches of low width and slope. Overall, the coastline of Alexandria can be divided into three categories:

(i) Naturally vulnerable coastal areas or ‘seriously eroding areas’:

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4 Based on the Medvedev-Sponheuer-Karnik (MSK) scale of seismic intensity
• Flat and low-lying coastal plain such as the western backshore zone of Abu Quir Bay and El Tineh plain
• Deltaic coastal plain areas affected by subsidence such as Abu Quir
• Beaches of Alexandria, from Mandara to El Silcila, are experiencing chronic long-term erosion of ~20 cm/yr because of ongoing natural coastal processes. More than 50% of the sandy beaches between El Montaza and El Silcila, 14.5 km long, have significantly disappeared following seaward widening of the Corniche highway constructed between 1998 and 2002, creating “sediment starved” coastal cells.

(ii) Artificially protected coastal areas. These areas are at risk of any structural failure during a major tsunami or coastal storm. Examples of such areas in Alexandria are:
• Abu Quir seawall along the Nile delta coast: this old structure has an elevation of 1.4m above mean water level and is 10 km in length. It was initially built in 1780 to protect the low-lying land behind it from sea flooding, for agriculture purposes. Between 1983 and 2010, this wall was reinforced many times. However, possibility of breach or break during a major tsunami or coastal storm cannot be excluded.
• Corniche Road and adjacent beaches are artificially protected by structures (breakwaters, groins, concrete or rock armor layers) that require periodic maintenance. These structures are also at risk of failure in case of severe storm.

(iii) Remaining areas along the Alexandria coast can be considered safe or ‘naturally protected safe areas. These include:
• The rocky carbonate ridges acting together to protect the low-lying areas south of the city and west of Abu Quir land.
• The coastal dune defense system fronting the backshore of Abu Quir Bay.
• Shore parallel-accretion sandy ridges exist at some localities along the Nile delta coast particularly the central part of Abu Quir Bay.

Flooding
Overall, Alexandria faces a low risk of floods due to heavy rains during winter storms (reaching 96 mm/day for a 100 years event). Recently urbanized areas, which are below sea level such as those between the hydrodrome and Abu Quir, at the edge of the former Abu Quir lagoon, in Sharq and Al-Montaza districts, are susceptible to flooding.

Although the overflows at manholes or pumping stations during winter storms (squalls) are frequent, no significant damage because of flooding has been reported. The urban drainage basins of the Alexandria conglomeration do not show real hydrographical pattern with well-identified drainage channels (wadis). Due to the arid climate, rainfalls are scarce and do not require specific hydraulic facilities. In Alexandria, runoff water is therefore managed together with wastewater in a combined sewage and drainage network. This network has been improved and upgraded during the last decades, but its discharge capacity is low (equivalent to a 2-year flood event), so overflows at manholes or pumping stations during winter storms (squalls) are frequent. These floods are of limited extent and usually do not exceed a few hours. As a result, no significant damage because of flooding of the urban areas of Alexandria has been reported, but traffic can be temporarily disturbed.
Most of Alexandria’s drainage waters flow towards Lake Maryut, together with the wastewater, through two treatment plants. The lake water level is kept between -2.8 to -2.6 m below sea level, in order to facilitate the drainage of the surrounding agricultural areas. The Lake Maryut pumping station discharges the excess water into the sea. Flood simulations carried out within the framework of the present study show that even for a 100 years event, the lake level does not rise more than a few decimeters, so the impact in terms of possible flooding of the lakeside urban areas does not seem significant, considering pumping stations are operational.

**Water Scarcity**

The water resources of Alexandria are becoming scarce, however the current risk of water scarcity is low as the current water supply meets current needs. The current water needs are estimated to be between 4.5 million m$^3$/day (2.5 million m$^3$ drinking water, 1 million m$^3$ industrial water, and 1 million m$^3$ agricultural water) for the summer months and 3.80 million m$^3$/day (2.0 million m$^3$ drinking water, 1 million m$^3$ industrial water and 0.80 million m$^3$ agricultural water) for the winter months. Water supply from the Nile River through the Al-Mahmoudeya canal (5 million m$^3$/day discharge) covers the current needs.

Surface-water resources originating from the Nile via the Al-Mahmoudeya Canal are now fully exploited, while groundwater sources are being brought into full production. With only 31 Million m$^3$/year, compared to at least 1 825 M m$^3$/year for the Al-Mahmoudeya Canal, groundwater resources do not count much. Moreover, aquifers are partially salinized and unsuitable for human consumption. Alexandria is facing increasing water needs, demanded by a rapidly growing population, by increased urbanization, by higher standards of living and by the agricultural policy, which emphasizes expanded production in order to feed the growing population. Moreover, almost half of the Egyptian industrial activity is located in Alexandria, and this sector is the major contributor of water consumption in the Alexandria urban area. In the last ten years, there has been a 50% rise in the water demand.

*Climate change is expected to worsen the natural risks by 2030*

Compared to current situation, natural hazard risks are expected to increase by 2030 due to climate change and urban growth, with high marine submersion and coastal erosion risk expected around El Dekheila, Western harbors, and at Abu Quir areas. Risk of water scarcity is expected to be high in future, as growing water demand would exceed the supply capacity by 2032, together with possible hydrological changes and uncertain geopolitical context in the upstream part of the Nile basin. Seismic risk may also increase with greater exposure and growing land subsidence effect. Risk of flooding is also expected to increase due to increased exposure and climate change impacts. Additionally, climate change may negatively affect public health, with a potential increase in diseases such as diarrheic diseases and malaria.

* Climatic projections to a horizon of 2030 were made as part of this study using dynamic downscaling methods from the three ENSEMBLES European project models with IPCC scenario A1B, and the Météo-France ARPEGE-Climate model with IPCC scenarios A1B, A2 and B1. These modeling results estimate that the city of Alexandria will get warmer, on an annual scale, by +1.2°C to +1.9°C. There is, however, a very wide margin of uncertainty associated with increased heat waves. Changes in rainfall events are also accompanied by high levels of uncertainty (lack of
coherence between models or wide ranges of values). In this context, it has been decided to consider results of the METOffice Hadley Centre model together with A1B scenario as a “worst case” scenario, for which extreme precipitation increases respectively by 7% and 30% for the 10 and 100 year return periods.

Based on a critical analysis of the IPCC’s projections and the latest references in the literature on the subject, a global rise in sea level of 20 cm by 2030 is assumed for this study. It should be pointed out that this is a high projection, and that the trends in sea level rise currently measured on Alexandria are much lower. High projections will help in simulating and planning for worse scenario that can result from Climate Change.

Climate Change will affect natural hazards, except those of geological origin such as unstable natural terrain and earthquake risks. Climate changes will also result in aggravation of climate related diseases such as diarrheic diseases, and malaria. The following sections outline the effect on natural hazards by 2030, taking into account the impact of climate change:

Coastal erosion and marine submersion

Coastal erosion and submersion risks are expected to be high by 2030 due to sea level rise and urban expansion. The risk of coastal erosion is expected to be highest between El Dekheila and the western harbors, and at Abu Quir. The storm surges may increase, with resulting damages to sea walls and other shore-front structures. The coastal areas of Abu Quir are directly threatened by marine submersion, and the low-lying areas of the former Abu Quir lagoon by possible breakage of the old Mohammed Ali sea-wall, built in the 18th century. This situation requires preventing any new settlements in this agricultural area.

In spite of numerous projects for coastal protection, a rise in sea level will reactivate or amplify the process of coastal erosion, and therefore receding of the coastline. The sandy beaches still in their natural state risk receding on average by 10 to 15 m by 2030. In the urbanized areas, which are already protected by structures or protective works (widening of beach by massive replenishment with sand, then periodic maintenance, installation of structures blocking the sand laterally), retreat will be slower but nonetheless inexorable. In case of storms combined with high water levels, beach head works in urbanized areas risk severe damage, as the width of the beach is not sufficient to dampen the effects of the swell as too close to the high tide line. The sandy beaches remaining in their natural state will be totally submerged and will recede significantly. However, they should be able to partially reconstitute in periods of fine weather, and almost entirely when the beach head consists of dunes.

Flooding

The conditions of flooding may worsen because of the combined effect of climate change (despite uncertainties, more extreme rainfall events may be expected with additional 30% for the 100 years event) and increasing urbanization (non-absorbing soils). A ‘medium’ flooding risk (compared to low risk in current situation) can be expected in areas below sea level, between the hydrodrome and Abu Quir, and at the edge of Abu Quir Lagoon in Sharq and Al-Montaza districts. Overflows of the present sewerage network may become more frequent, leading to damages to ground floor of buildings due to flooding.
The combined effects of climate change and urban growth may double the water level rise in Lake Maryut for a 100 years flood. Nevertheless, the situation should stay manageable with regard to the present pumping capacity and water level regulations.

Water Scarcity

The risk of water scarcity is ‘high’ for 2030 scenario as the 50% increase in water needs observed during the last 10 years is expected to continue. With a maximum supply capacity of 11 million m$^3$/day, and taking into account the current consumption growth, the Al-Mahmoudeya Canal supply capacity would be exceeded by 2032. Although climate change projections for the Nile River basin are difficult to carry out, we can assume that the growing needs of all the countries of the catchment’s area will significantly affect the resource availability.

**Current and future urban sensitive components**

Urban components within Alexandria city, which are most vulnerable or sensitive to the impacts of climate change or future disasters, are (i) informal or slum areas, housing one third of Alexandria’s total population; (ii) old and deteriorating buildings and infrastructure; (iii) new construction over reclaimed wetlands and other low-lying areas, facing enhanced land subsidence and flooding risks and, (iv) buildings and infrastructure facing the coastline, which are at risk of marine erosion and submersion. Fast urbanization of surrounding areas will further increase the vulnerability of the city, with the appearance of new urban patches on sites exposed to hazards and by expansion of informal settlements in low lying areas exposed to flood and seismic risks.

The city of Alexandria, with over 230,000 ha area and a current population of about 4.3 million people (in 2006) is witnessing fast population growth. Urban sensitive or vulnerable components within Alexandria city are:

(i) **Informal or slum areas**: The informal or slum areas covers about 3.25% of the total area of Alexandria but represent about 35.4% of Alexandria’s total population. These areas are mainly located in the central city area (Al-Montaza and Sharq districts) and are characterized by high population density, bad building conditions, absence or bad conditions of infrastructure, and high percentage of people living below poverty line. Moreover, buildings within informal settlements are mostly made of masonry, which is more vulnerable to seismic risk. Their location coincides with areas of strong subsidence determined by interferometry analysis. Because of the bad geotechnical context, these areas are also at high risk of earthquake. It is also likely that some of these areas are below sea level (at the edge of the former Abu Quir lagoon), involving drainage and sanitation issues. (ii) **Deteriorating buildings and infrastructure in the central city**: Dense, old and deteriorating buildings and infrastructure from central city to the east as well as from the west at Al-Ameriya district to New Borg Al-Arab city are at seismic risk. Despite poor standards of construction, residential buildings are mostly made with reinforced concrete, and can be considered – according to current seismic classifications (see Section 2.1. in Chapter 6 – Economic Evaluation) – at moderate seismic risk. However, the bad condition of some of these buildings, especially in the Gharb district constitutes an aggravating factor.
(iii) **New construction in hazard prone areas**: Reclaiming wetlands and other low-lying areas for construction put future population at risk of damages from potential earthquake, land subsidence or flooding.

(iv) **Buildings and infrastructure facing coastline**: Urban components likely to be affected by the coastal erosion and marine submersion risks are port facilities, coastal roads, and dwelling houses on the coastline directly exposed to these risks. The sanitation system is highly sensitive to heavy rains, and in case of overflow, streets and tunnels may be flooded.

According to future population estimations from the Governmental Organization for Physical Planning (GOPP), Alexandria may reach a population of 6 million inhabitants in 2030, following a **40% population growth**. This major growth will translate itself in the urbanization of surrounding areas, threatening critical natural resources, such as Lake Maryut, which currently play a critical role in the management of drainage of water prior to their discharge into the sea. The strategic planning documents developed by the Governorate of Alexandria show major direction of urban expansion westwards, along both shores of Lake Maryut. However, given the recent trends, it is assumed that urban sprawl will also continue south of the city, between Maryut Lake and Abu Quir.

In terms of vulnerabilities, the cumulative effect of these changes may be an increased exposure of the poorer populations (precarious living conditions), the appearance of new urban patches (major projects) on sites relatively exposed to climatic risks (Abu Quir depression, Maryut Lake, shoreline) and by expansion of informal settlements in hazard prone areas. In particular, an urban expansion South of Al-Montaza and Sharq district is likely to occur in low-lying areas exposed to flood and seismic risks.

**Cost of disaster risks and climate change impacts**

Although full costing of potential economic impacts of climate change and disasters was not possible for Alexandria due to the unavailability of precise Digital Elevation Model, some quantitative estimates were possible for likely impacts on health, water resources, and earthquake risk. Based on initial estimates, natural disasters and climate change impacts would cost the city of Alexandria approximately $1.72 billion (in Net Present Value) during 2010 to 2030 period. Climate Change related impacts are estimated to be around 18% of the total estimated cost.

The methodology for assessing economic impact of climate change and natural disaster risks strongly relies on urban vulnerabilities projection for 2030 and a good characterization of the hazards, based on GIS outputs. Since reliable Digital Elevation Model and quantitative estimates on future urban development scenarios were not available, a thorough economic assessment was not possible. Some quantitative estimates were possible for health impacts due to climate change and water resources, since they do not directly rely on spatial data, as well as earthquake risk, which can be considered homogenous in the area considered.

The total annual costs of disasters considered by the study, and for which cost estimation was possible, taking into account climate change, are estimated at $1.72 billion or 10 billion Egyptian Pounds for 2010 to 2030 period.

With respect to climate change related health issues (mostly diarrheal diseases, and malaria), the total annual average costs are around 278 M EGP, equivalent to about 0.30% of the city's annual GDP. The indirect costs are estimated at around three times the direct costs. It is important to note
that the health costs due to climate change are based on a number of assumptions, and thus should be taken as very rough estimate.

**An institutional set-up in need of improvement**

While natural risks are growing, the institutional capacity in Alexandria to manage these risks and prepare community for potential future disasters and climate change impacts is limited. The current organizational set-up remains highly centralized with limited coordination between agencies horizontally and vertically down to the level of communities. The analysis undertaken as a part of this study shows not only the need for greater financial and decision making authority at the local level, but also for inter-agency coordination to ensure local ownership and effective implementation.

Egypt is slowly moving from a reactive approach of managing disasters and climate change, which relies primarily on emergency response, to a more pro-active approach of risk reduction and preparedness. Till now, the Egyptian government has focused on post-disaster relief and rehabilitation activities, as evident in the rescue and relief efforts following past disasters. Less attention to adopting prevention measures against major natural risks may be because of relatively moderate impacts of past disasters in the country. However, recent disaster events, such as Cairo’s Moqattam September 2008 landslide (rockfall and slope collapse leading to the loss of 107 lives) burying the Duweiqa informal settlement, points to rising vulnerability resulting from poorly constructed and maintained buildings and infrastructure, settlement of population in hazard prone areas, lack of infrastructure to ease rescue efforts, absence of early warning system and inter-agency protocols in case of crisis. Slow-onset disasters such as water scarcity and other risks resulting from climate change may further aggravate the existing vulnerability.

From 2000 onwards, the national government passed various decrees to establish the legal and institutional basis for disaster risk management and climate change adaptation. The current structure for disaster management and response follows a highly centralized organizational set up, with the Information and Decision Support Center (IDSC), under the Egyptian Cabinet, as national coordinator for Crisis Management and Disaster Risk Reduction, and the Civil Protection Administration, the Ministry of Interior, acting as the operational arm. The IDSC plays a pivotal role in the coordination of disaster-related crises, and more recently in managing risks related to disasters (in 2005 after Egypt signed the Hyogo Framework of Action in 2005) and climate change. Other scientific and technical entities active in the field of disaster and climate change risk assessments are the Egyptian Meteorological Authority and the Egyptian National Seismic Network (ENSN).

While the near-vertical geometry of the Egyptian State’s structure minimizes horizontal overlap between the tasks and the duties of two or more neighboring entities, the local government appears to have limited resources and decision making power. For example, the Physical Planning Center for Alexandria Region is entrusted with the preparation of urban master plans, but their validation and issuing still remain with the central GOPP. The Civil Protection Administration plays an important role in emergency response with a focus on rescue and relief operations, and training of personnel in crisis management. At a local level, the Decree of the Minister of Interior gave the authority to establish regional Civil Protection units under the leadership of the Governor to respond to emergencies, with operational equipments and trained personnel for rescue and relief operations. Other national agencies that are involved in natural risk management at local scale in Alexandria are the Ministry of State for Environmental Affairs Agency, EEAA: Alexandria Regional Branch Office, the Coastal Protection Authority, the Alexandria Sanitary Drainage Company, and the Lake Maryut
Management Authority. These agencies’ mission is to enforce laws, develop erosion, flooding, and marine submersion control projects.

Local authorities, who were interviewed in Alexandria within the framework of the present study, called for adopting a more decentralized approach in decision making, and for widening the mandate of the Governorate and local institutions in disaster management. Insufficient involvement of the Environmental Management Unit, lack of financial resources, lack of inter-authority coordination (no regular meetings held), and severe deficiency in law enforcement were also considered to be the most urgent faults to repair.

A case study of 2010 Sinai flash-flood was undertaken as a part of this study. This case study is comparable to 1972, 1979, 1991 and 1998 floods in Alexandria. The case study highlights the need for significant and continued investments in early warning and communication, together with a strong focus on emergency response needs. Overall, although there has been some progress in multi-agency coordination in the last decade, further improvements are required in timeliness, coordination, and effectiveness of the national system of monitoring and early warning. It is recommended that multiscale preparedness and response may still rely upon the present system(s), with the provision of a few key technical improvements targeting efficiency and robustness.
### Vulnerabilities and Risks in Alexandria – Synthesis Table

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Time Horizon</th>
<th>Urban Sensitive Components</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground instability / seismicity</td>
<td>2010</td>
<td>Dense urban areas with bad building conditions and slum settlements.</td>
<td>Type (casualties excluded)</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>Same components.</td>
<td>Location (see Phase 1 report)</td>
</tr>
<tr>
<td>Tsunami / marine submersion</td>
<td>2010</td>
<td>Preserved natural shore and densely urbanized coastline.</td>
<td>Especially in Gharb district Al-Montaza and Sharq districts (see Figures 96 and 100)</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>Same components, but growing urbanization of the shoreline and progressive disappearance of natural areas.</td>
<td></td>
</tr>
<tr>
<td>Coastal erosion</td>
<td>2010</td>
<td>Preserved natural shore and densely urbanized coastline.</td>
<td>Structural damages to buildings on seastfront; submersion of low lying areas.</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>Same components, but growing urbanization of the shoreline and progressive disappearance of natural areas.</td>
<td></td>
</tr>
<tr>
<td>Flooding</td>
<td>2010</td>
<td>Recently urbanized areas below sea level, between the hydrodrome and Abu Quir, at the edge of the former Abu Quir lagoon, in Sharq and Al-Montaza districts.</td>
<td>Inundation of ground floors (damages buildings)</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>Same components. No planned urban development in the sensitive areas (below sea level), but informal settlements may happen if no strict regulation is implemented.</td>
<td>See Figures 105 and 112</td>
</tr>
<tr>
<td>Water scarcity</td>
<td>2010</td>
<td>Population and economic activities (water needs). The industrial sector is the major contributor of water consumption growth.</td>
<td>Water shortage</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>Same components, but growing needs by 2030 (the 50 % increase observed in the last 10 years may continue at the same pace)</td>
<td>The whole Governorate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Moderate exposure but some damages may appear because of « site effects » (unstable ground); intensity ranging from VI to VI-VII MSK in areas of strong subsidence (site effect).</td>
</tr>
<tr>
<td>Medium</td>
<td>Same intensity, but probable continuation of subsidence effects.</td>
</tr>
<tr>
<td>High</td>
<td>Same as the present situation. However, possible rupture of the Abu Quir sea wall (if not properly maintained) would result in the submersion of residential areas.</td>
</tr>
<tr>
<td>Medium</td>
<td>Same as the present situation + high erosion risk on the whole shoreline West of El Dekhila harbor (expected 10-20 m of shoreline retreat compared to the present situation)</td>
</tr>
<tr>
<td>Low</td>
<td>Heavy rains during winter storms (squalls) reaching 96 mm/day for a 100 years event. Despite undersized combined sewerage, no significant flooding issues reported by local authorities. No significant impact on the lake Maryut level (+ 32 cm).</td>
</tr>
<tr>
<td>Medium</td>
<td>Despite uncertainties, more extreme rainfall events may be expected (+ 30% intensity for the 100 years event). Areas around lake Maryut should not be significantly affected (+ 42 cm with climate change; + 58 cm with CC and urban development).</td>
</tr>
<tr>
<td>Low</td>
<td>Water supply from the Nile River, via the Al-Mahmoudeya Canal (5 M m$^3$ of daily discharge). Covers the Governorate’s current needs (4.5 M m$^3$).</td>
</tr>
<tr>
<td>High</td>
<td>With a maximum supply capacity of 11 M m$^3$ day, and taking the current consumption growth into account, the Al-Mahmoudeya Canal capacity would be exceeded by 2032. Moreover, despite the fact that Egypt is well adapted to current climate variability, thanks to the High Aswan Dam, climate change and geopolitical issues may change the country allocation of Nile waters.</td>
</tr>
</tbody>
</table>
Chapter 4 – Objectives and Orientations

1. Introduction

The present chapter provides the unifying thread (or storyline) between the outcomes of the first study phase and the actions developed in the second one. The purpose is to establish the links between the stakes identified in the diagnosis phase and the recommendations expressed in the present report.

For each main theme addressed in Phase 1, the main outputs regarding risks and vulnerabilities are explained or highlighted, i.e. the main points on which Phase 2 recommendations have to focus on. These recommendations are expressed in terms of objectives and orientations, with reference to the corresponding action sheets, that provide all the information required on the recommendations.

The following themes are considered:

- Institutional Support
- Urban Planning
- Management and monitoring of Ground Instability / Seismicity
- Control of Coastal Erosion and Marine Submersion (storm surges and tsunamis)
- Flood Control
- Water Resources Management

The two first points correspond to strategic orientations, encompassing risks on global and transversal ways. The next ones relate to a relatively technical and monothematic approach of the risks and vulnerabilities. It is therefore not surprising to find in urban planning or institutional considerations some aspects developed under a technical standpoint in other sections.

2. Institutional Support

The analysis of the Egyptian structure for managing natural, environmental and Climate Change related risks, carried out in the Phase 1 study, allowed singling out structural weaknesses that were considered relevant, as they do affect the overall performance of the system. Conversely, the analysis could not enter effectively the structure at the Alexandria Governorate level, the actual target of the project, as available information was poor. Since local systems in Egypt are basically structured as the downscaled copy of the national one, with lesser prerogatives, the results of the analysis and the suggestions that arise from them can be readily customized to (any) Governorate level.

In the analysis and the related suggestions, the Consultant has not entered the purely political debate of the large structural choices, which are not discussed and are taken as the entry data to the problem. Highlighted solutions remain mostly technical as technical weaknesses must be overcome and cannot be replaced by a different work organization. Especially in fields
where human lives and State wealth are threatened, decisions should rely upon facts (data). In summary: knowledge first.

**Recommendations Criteria**

Phase 1 analysis allowed stating that, in the opinion of the Consultant, weakness points in the efficiency of the Egyptian framework are (a) a redundancy in the decision tree, with (b) the technical decision being mostly disconnected from the (c) operational decision that is taken in the Operation Room. Another point is that (d) even though Governorates are provided with their own structure, there is little automation in the action as the decision is dependent on an information that is usually available at a broader scale in national networks.

It was found essential, therefore, to stress the need of improving the observation capacity in terms of quality, quantity and timeliness of monitoring. This is expected to reflect, in turn, into an improved capacity of modeling the observables and transforming them into forecasts (a capacity not lacking at all in Egypt), the project team sees two steps as above, are the way to effectively come into full control of the territorial situation, as to give rise to the implementation of a full C^3I system (Command, Control, Communication, Information).

In consideration of the geographical stretch of hazards jeopardizing the Alexandria area, it is expected that slow-impacting hazards – as the Climate Change driven ones – are accurately monitored and evaluated on spot, whereas the distant or distributed sources of fast-impacting events (earthquakes, tsunamis, meteorological extremes) are relayed from a broader, national/international observation-and-modeling network. This should enable the Governorate to take only operational decisions, on the grounds of best available expertise located abroad and timely homed, with an expected, significant improvement in the action quality and timeliness.

The possible financial scheme (insurance), searched for in the sake of ensuring sustainability of the costly risk mitigation actions investigated and/or proposed in this project, could be enacted and run only if sufficient means for evaluating (first) and controlling the risk evolution with time (second) will be available and reliable.

**Suggestions for improvement and innovation**

- **Improvement of institutional coordination (see Sheet 1)**

This sheet gives some recommendations to improve technical coordination in natural disaster preparedness and climate change adaptation at the Ministerial and Governorate levels.

- **Strengthening Monitoring and Early Warning (see Sheet 2)**

In the last fifty years, Egypt was hit with about yearly frequency by minor events of meteorological and (flash) flood nature, and one moderate magnitude earthquake in 1992. No event concerned the Alexandria area, whose last natural event was the moderate magnitude, 1954 earthquake. The infrequent occurrence of events requiring strong response and recovery effort had probably a role in the overall improvable performance of the national system; whereas little is known about dimension and performance of the system at the Governorate level in Alexandria. Consequently, the first recommendation deals with a set of urgent, structural actions to assist in improving preparedness and potential of response at the national level. Improved capacity in monitoring the territory, and modelling and forecasting natural disasters in the short term, is considered to be the main pathway to come in control of the slow approaching, and (later) fast impacting effects of Climate Changes.
Preparation and self-protection against fast-impacting phenomena (see Sheet 3)

The aim is to prepare and enable exposed populations to initiate and carry out timely, autogenous, self-protection and impact mitigation actions in advance on structured responses of Civil Defence/Civil Protection bodies or their equivalent. Training based on lessons learnt by frequently striking events (flash-floods, e.g.) and on synthetic scenarios for events characterized by low to very-low repetition rates (storm surges or even tsunamis, e.g.).

Insuring Natural Risks (see Sheet 4)

Even in presence of significant human, material and financial resources, the improvement of Natural Hazard resilience requires a mechanism for ensuring sustainable endurance. The project team has explored a natural risk insurance scheme to apply to individuals, corporate and Institutional entities in the target site of Alexandria, once and where resiliency improvements against slow- (sea level change) and fast-impacting hazards (earthquake, and tsunami or storm surge flooding) will be completed. The candidate mechanism – inspired by existing examples on earthquake risk insurance worldwide – foresees reinsurance and responsibility sharing, at the appropriate level, between large insurance/reinsurance companies and the State.

3. Urban Planning

The First Phase Report on the ‘Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa – Alexandria Area’ included a comprehensive analysis of the different natural and socio-economic systems and characteristics of Alexandria. It covered risk assessment in the current situation and in 2030. A list of new vulnerabilities was also identified and spatially allocated on a map. In Summary, the First Phase report pinpointed the following main issues directly affecting urban areas, and requiring priority actions and immediate interventions in order to increase the city preparedness towards possible climate change risks and disasters:

- The city of Alexandria expands linear in high densities. Its geomorphology includes a coastal ridge(s) delimited from the north by the Lake Maryut depression, as well as rural land, some of which is below sea level. According to future population estimations, Alexandria may reach 6 million inhabitants in 2030. This major growth will be allocated in new urban expansions around the city, and will impose threats on critical natural resources, such as Lake Maryut and El Mex Bay, both playing a critical role in the management of drainage waters prior to their discharge into the sea. The cumulative effect of this change may be the expansion of informal settlements on low lands that are prone to natural hazards, flood and seismic risks.

- Although there is an overall improvement of quality and efficiency of Command and Control procedures during last decade, attention should still be paid to the improvement of timeliness, coordination and effectiveness of the national system of monitoring and early warning.

- The conditions of coastal erosion and submersion in particular will be affected by a rise in sea level that is assumed to reach 20 cm by 2030 (It should be pointed out that the current trends in sea level rise currently measured on Alexandria are much lower). In spite of the current and planned coastal protection measures and constructions, a rise in sea level will amplify the process of coastal erosion, and therefore receding of the coast line. In case of storms combined with high water levels, beach head works in urban areas risk severe damage. The coastal zone considered within the framework of the present study of highest
erosion risk is located between El Dekheila and Western harbors, and at Abu Qir. The sea level rise will not significantly affect the submerged terrain in 2030. However, the storm surges will be increased and the sea-walls may experience more damages in the future. The coastal areas of Abu Qir are directly threatened by marine submersion and the low lying areas of the former Abu Qir lagoon by possible breakage of the old Mohammed Ali sea-wall, built in the 19th century. This situation requires prevention of any new settlements in the area.

In response to the above-mentioned threats and risks the Second Phase of this study includes several strategic urban planning interventions that could be categorized as follows:

1. Interventions related to the institutional preparedness and the adaptation of planning and building regulations (Sheet 5). This type of actions includes a proposal to initiate the preparation and implementation of a set of mandatory requirements for local climate change policy to be incorporated within building and urban planning regulations and norms. It also includes a recommendation to formulate a monitoring and follow-up mechanism, possibly affiliated to the newly established national and urban observatories.

2. An action plan regarding the support of a long term urban management mechanism that ensures the implementation of a city-wide urban management scheme that reflects proactive measures against possible climate change risks and threats (Sheet 6). This action aims at providing the adequate institutional structure to implement all mitigation and adaptation measures on a long term perspective. It also builds on the existing GOPP/UNDP initiative to prepare a strategic plan and an urban management structure for Alexandria.

3. Urban planning interventions that mitigate flood and sea level rise threats in existing vulnerable areas, namely Abu Quir and El Max (Sheets 7 and 8). Both areas are prone to natural threats and include important national and local socio-economic assets. The purpose of those actions is to shift the emphasis of the disaster management from post-disaster response to pre-disaster proactive actions involving preparedness and prevention.

4. Prototyping an urban planning scheme in a new expansion area that promotes a best practice in adaptation to and control of climate change (Sheet 9). A special emphasis is given to those areas susceptible to flood and seismic risks. The action is not limited only to vulnerable areas but could also be implemented as a best practice in other city expansions and new settlements, through investigating three main themes: urban form, lifestyles and energy sources. This action could be included as a component in the Governorate’s priority projects implemented through the Alexandria Strategic Urban Plan (SUP).

It is worth-mentioning that all of the urban actions are affiliated to current and existing development activities (SUP preparation, new building and planning unified law, National urban observatory, Governorate’s priority projects, etc…). The main purpose is to produce intervention proposals that are implementable within the current institutional frameworks and mechanisms.

Based on the proposed actions the local and national knowledge and preparedness for natural disasters caused by climate change could be improved. Long term mitigation and protection measures could enhance the city's future and the well-being of its inhabitants.

Seismic risk is one of the major risks for which we cannot act on hazard (probability that an event with a given intensity occurs). Thus, the only way to reduce the risk is trying to predict earthquakes (forecast), reducing the effects (prevention), and improving preparedness.

Forecasting is the search for a set of methods allowing for the prediction of the date, location and magnitude of an earthquake to come. **Regarding seismic risk, the only possible forecast at present is the long-term forecast.** It relies on the analysis of the historic and instrumental seismicity (earthquake recurrence) and the identification of active faults. It involves evaluating a region’s seismic risk, in other words, the probability that an earthquake with a given intensity occurs. This evaluation is conveyed in the form of seismic zoning.

One of the main components of preventing seismic risk is the application of antiseismic regulations for buildings. These antiseismic construction rules deal with: reference seismic motion, ground type on the site, quality of the materials used, general design of the structure (which should combine resistance and deformability), assembling of the various components which form the building (chaining), and satisfactory performance of the works. At present, for commonly-used buildings (no strategic issue), it is generally selected that in the case of “design” tremors, i.e. with theoretical maximum intensity set in accordance with each seismic area, the building can be subjected to irreparable damage, but it should not collapse on its occupants. In the case of more moderate tremors (see Sheet 12), the application of the provisions defined in the antiseismic regulations should also allow destruction and, therefore, economic losses, to be limited. For the other types of structures, greater return periods, or/and increases in the seismic coefficient, may be imposed. The return period (or increase coefficient) depending on the type of building is a political choice. Regarding common buildings, a certain number of countries have selected the period of 475 years (which corresponds to a probability of 10% for each 50 years that the reference motion may occur).

The development of an antiseismic regulation for the application of antiseismic standards for buildings **firstly requires the definition of reference seismic motions** which will be taken into account for the measurement of the structures. This definition **results in the realisation of national regulatory seismic zoning.**

Concerning Egypt, a building code was first enforced in 1964, yet the first comprehensive building code covering concrete structures, soil mechanics & foundation and electrical connections in buildings was published in 1980. The provisions of calculations of the seismic effects on buildings and bridges in the Egyptian building code were completely revised in 2001 and 2006 also taking into account the Eurocode 8.

For Alexandria, Phase 1 of the present study showed that the probability of occurrence of a seismic event likely to generate damages or casualties was not nil. However, in the next 100 years, the **probability of occurrence of an event of very high intensity level is relatively low.** Hence, it is estimated that the return period of:

- 475 years corresponds to a seismic intensity VI MSK
- 100 years corresponds to a seismic intensity V-VI MSK
- 50 years corresponds to a seismic intensity V to V-VI MSK
- 20 years corresponds to a seismic intensity IV-V V MSK.
These evaluations were conducted on the basis of publications and catalogues describing historical and contemporary events, and several works devoted to the evaluation of seismic hazard in Egypt.

With the aim of getting a better knowledge of the seismicity levels in Egypt (catalogues of instrumental earthquakes, location of active faults and characterization of their seismicity), it is necessary to **develop the national seismic network** (see Sheet 10).

According to the new building code, **Egypt is subdivided into five seismic zones**. Alexandria is located in zone 2 of the national zoning, corresponding to the value of PGA between 0.1g to 0.125g. Our results are consistent with those of the national seismic zoning currently used in the regulations for Earthquakes-Resistant Design of Buildings in Egypt. However, the geological context of Alexandria shows that in some areas, amplifications of the seismic motion are possible. Consequently, a **seismic micro-zoning**, that is to say mapping and characterization of areas with possible site effects, is highly recommended (see Sheet 11).

According to the new building code, unreinforced masonry is not permitted only in seismic zones 4 and 5, and it is strongly suggested to use reinforced concrete frames with masonry walls in these zones. However, several historical earthquakes have shown that even with moderate seismic intensities (IV-V to VI), there could be major damages in particular for the old and adobe buildings. It is therefore recommended to perform an **assessment of the vulnerability of existing buildings** (see Sheet 12).

5. **Control of Coastal Erosion and Marine Submersion**

With respect to the **tsunami hazard**, far seismic sources may cause tsunamis of high intensity, especially the active faults of the Aegean arc. Phase 1 study has shown that strong tsunamis (5-6 intensity scale Sieberg-Ambraseys) have already caused considerable damages to the Alexandria’s coast during the last two millennia (365 and 1303 AD). The return period of strong tsunamis is estimated between 400 years and 800 years. The return period of tsunamis of medium intensity (level 3 of Sieberg - Ambraseys) is estimated between 100 and 200 years, while tsunamis of lower intensity (level 2 of Sieberg Ambraseys) would have a return period of 10 to 50 years. Thus, the tsunami hazard in Alexandria is real, but rather low.

Several countries around the Mediterranean Sea are currently developing and installing a **tsunami warning system**. To be consistent with this regional approach, Egypt should define and organise a tsunami downward warning system. It should be operational by the same time as the upward warning system (see Sheet 13).

Besides the need to **refine knowledge on the possible tsunamigenic sources** (near or far) and the probability of occurrence of the corresponding tsunamigenic rupture (see Sheet 14), it is necessary to **improve the cartography of the tsunami risk** (hazard, vulnerability and risk assessment) on the coastal sectors which are, in theory, the most exposed (high susceptibility in terms of tsunamis and/or high stakes), see Sheet 15.

The Alexandria coast consists of more or less extensive sandy beaches separated by rocky outcrops. Beaches are experiencing **chronic long-term erosion** because of ongoing natural coastal processes combined with sediment deficiency in its littoral system, and development projects such as the seaward widening of the Corniche highway.
The coastal area is also subject to **submersion risk**, most evident during stormy periods. Storm surges in association with spring tides (high tides) raise water levels by 60cm above normal. Occasionally, high tides occur in combination with storm surges, and sea level can produce **wave set-ups of 1.6 m**. Such storm surges can submerge the shoreline but low lying areas expanding around Lake Maryut and South of Abu Quir are protected by natural ridges or sea walls.

In the future, the conditions of coastal erosion and submersion in particular will be affected by a **rise in sea level** arising indirectly from global warming, via thermal expansion of the water and melting of the polar icecaps. Based on a critical analysis of the IPCC’s projections and the latest references in the literature on the subject, it is assumed from this study a maximum rise in sea level of 20 cm by 2030.

In spite of numerous projects for coastal protection, a **rise in sea level will amplify the process of coastal erosion**, and therefore receding of the coastline. **The risk level can be classified as “high”**. The sandy beaches still in their natural state risk receding on average by 10 to 15 m by 2030. In the urbanised areas, already protected by structures or along which protective works are projected, retreat will be slower but nonetheless inexorable. In case of storms combined with high water levels, beach head works in urbanised areas risk severe damage, as the width of the beach is not sufficient to damp the effects of the swell. The sandy beaches remaining in their natural state will be totally submerged and will recede significantly. However, they should be able to partially reconstitute in periods of fine weather, and almost entirely when the beach head consists of dunes. The coastal zone considered within the framework of the present study of highest erosion risk is located between El Dekheila and Western harbors, and at Abu Quir.

The sea level rise will not by itself induce significant submersion. However, **the storm surges will be increased and the sea walls and other coastal infrastructure may experience more damages** in the future. During storms, the coastal areas of Abu Quir will be directly threatened by marine submersion and the low lying areas of the former Abu Quir lagoon by possible breakage of the old Mohammed Ali sea-wall, built in the 19th century. Here also, **the risk level can be classified as “high”**.

Addressing the present and expected situation regarding coastal erosion and marine submersion means implementing **the following recommendations**:

- improve knowledge on the changes of coastal beaches, through the monitoring of various physical parameters (see Sheet 16);
- Carry out specific surveys along the Corniche Road, in order to define the appropriate protection strategy of this sensitive coastal area (see Sheet 17);
- Prevent marine submersion risks by a set of protective measures to be implemented at the building scale, associated with a reliable submersion risk warning system (see Sheet 18);
- Strengthen the previous measures in the most vulnerable areas such as Abu Quir, through specific vulnerability studies, upgrading the fishing shelter and ensuring a sound maintenance to the El Tarh sea wall (see Sheet 19).
6. Flood Control

The urban drainage basins of the Alexandria conglomeration does not show real hydrographical pattern with well identified waterways. Due to the arid climate, rainfalls are scarce and do not require specific hydraulic facilities. In Alexandria, runoff waters are therefore managed together with wastewaters in a combined sewage and drainage network. This network has been improved and upgraded during the last decades, but the design rainfall is only a 2 years return period, so overflows at manholes or pumping stations during winter storms (squalls) are not rare. These floods are of limited extent and usually do not exceed a few hours. As a result, no significant damage because of inundations of the urban areas of Alexandria has been reported, but traffic can be temporarily disturbed.

Most of Alexandria’s drainage waters flow towards Lake Maryut, together with the wastewater, through two treatment plants. The lake water level is kept between -2.8 to -2.6 m below sea level, in order to facilitate the drainage of the surrounding agricultural areas. El Max pumping station discharges the excess water into the sea. Flood simulations carried out within the framework of the present study show that even for a 100 years event, the lake level does not raise more than a few decimetres, so the impact in terms of possible inundation of the lakeside urban areas does not seem significant.

The conditions of flooding may be worsened by 2030 because of the combined effect of climate change and increasing urbanisation (impervious soils). Overflows of the present sewerage network may become more frequent. The two combined effects of climate change and urban growth may double the water level rise in Lake Maryut for a 100 years flood. Nevertheless, the situation should stay manageable with regard to the present pumping capacity and water level regulation. The overall risk level can be classified as “medium”.

The following adaptations measures are recommended:

- Set up an early warning system, intended to forecast winter storms and risk of heavy rainfall events, and inform the population in real time (see Sheet 20);
- Control downstream runoff discharges in new urbanized areas or in urban renewal programs, through new storm water drainage constraints and specific devices implemented at the building plot scale (see Sheet 21);
- Update the Sewerage Master Plan in order to increase the protection level against floods (see Sheet 22);
- Control and reduce runoff discharges in already urbanized areas, as far as possible by direct discharge to the sea, or by infiltration (see Sheet 23);
- In the same areas, manage floods through a set of technical and organizational measures aimed at reducing the consequences of flood events (see Sheet 24);
- Ensure a proper cleaning and maintenance program of the sewage combined network (see Sheet 25).
7. Water Resources Management

The water resources in Egypt are becoming scarce. **Surface-water resources originating from the Nile River via the Al-Mahmoudeya Canal** are now fully exploited, while groundwater sources are being brought into full production. With only 31 M m³/year, compared to at least 1825 M m³/year for Al-Mahmoudeya Canal, groundwater resources are not significant. Moreover, aquifers are partially salinized and unsuitable for human consumption. Alexandria is facing increasing water needs, demanded by rapidly growing population, increased urbanization, higher standards of living, and by the agricultural policy which emphasizes expanded production in order to feed the growing population. Moreover, part of the Egyptian industrial activity is located in Alexandria, and this sector is the major contributor of water consumption in the Alexandria urban area. However, in the present situation, needs do not exceed resources.

The future flow of the Nile River is subject to complex projections which include the impacts of decreasing precipitations in other African countries and possible increases in agricultural uses at the source of the river, long-term impacts of the Nasser dam reservoir and increasing evaporation, and likely increases in water use in and around the Cairo agglomeration before reaching the Delta. So, **climate change projections at the Nile River basin are difficult to carry out**, but we can assume that the growing needs of all the countries of the catchment’s area will significantly affect the resource availability. **The risk level can therefore be classified as “high” by the year 2030.**

There are two main ways for addressing water resources issues in the coming years:

- Control and optimize water consumption for all uses, and improve efficiency of the water distribution network (see **Sheet 26**);
- Reuse (recycling) treated waste water and sludge, to reduce pressure on the resource (see **Sheet 27**)

8. Synthesis

In order to make it easier and more convenient to read, this chapter presents the action plan’s objectives and operational areas in a thematic way. It is however important to point out that, beyond the particular recommendations for a specific theme related to natural risks, **the management of these risks and the consideration of climate change is largely a matter for global and cross-disciplinary reflection**, because of the clear links that exist between certain themes (e.g. flooding and marine submersion), a shared and general approach to the risks (same prevention and management strategies), and synergies that are apparent in the preparation and work undertaken by government authorities.

It is particularly within the **institutional domain** that these synergies have the potential to carry the greatest significance. In fact, whereas prior management of risks (knowledge, prevention, monitoring, bottom-up alert) is mainly a matter for specialists in the various natural risks, from the moment that the risk is identified, the top-down alert (informing the people), crisis management and return to normal are the responsibility of the same government bodies and organisations (particularly the Civil Protection Administration). Any structural and/or functional weakness of the natural risk management system may therefore have serious repercussions whatever the nature of the risk. This is why recommendations related to institutional support are
at the very beginning of the chapter. Among these, the most significant - because they are the most cross-disciplinary - are without a doubt strengthening institutional coordination (Sheet 1), strengthening the monitoring and warning system (Sheet 2) and self-protection against disasters (Sheet 3).

**Urban planning** is the other major theme that allows a cross-disciplinary approach to risks. Furthermore, this field is the one that best reflects and integrates the risk prevention requirements, given that the institutional is always geared towards preparation. Through urban planning it is therefore possible to “prevent” (avoid) exposure to risks to future populations. In this respect, the first measure is the effective implementation and enforcement of building and urban regulations (Sheet 5). Urban planning, in particular, is the principal driving force for problems of coastal submersion or flooding (see Sheet 21).

The thematic approach to the risks (earthquake, erosion and marine submersion, flooding, water scarcity) is more technical. It is mainly aimed at reducing the hazards (e.g. sheets 23, 24, 25) and/or reducing the vulnerability of exposed populations and activities (e.g. Sheet 18). These costly protection measures are also of much less certain effectiveness than urban planning measures. In fact, they cannot offer protection beyond certain recurrence thresholds for harmful events. In the present case, defining these measures is mainly aimed at compensating for the potential impact of climate change, while maintaining the same protection objectives as those currently defined by local authorities. Only the problem of earthquakes and tsunamis, the recurrence of which is much more difficult to define and which is demonstrated on a much larger scale, is dealt with more through risk prediction and prevention measures.

We note that **the objectives and orientations of this action plan are completely compliant and consistent with the** National Action Plan on Climate Change, which has followed the signature of Egypt to the 1995 United Nations Framework Convention on Climate Change (UNFCCC). However this is placed at a level which is not sufficiently refined to be able to guide the direction of the present action plan.
Chapter 5 – Action Sheets

1. Methodological Framework

The recommendations have been prepared using a **sheet format**. Main advantages of such format: provide a digest (1 page or 2 pages max.); make sure that all points are dealt with (comprehensive) and in a consistent way (same presentation for all recommendations). The sheet format will also facilitate the structuring and organization of the action plan (numerical classification).

**Comments about the sheet legend:**

- **Sphere of intervention (strategy):** Infrastructure / Technical Measure; Urban Planning / Regulation; Institutional Preparedness / Training / Awareness. To comply with the project TORs, the recommendations are classified into one of these categories. However, some recommendations may belong to 2 or even all categories. That is why a diagram is included, showing the actual position of the recommendation with regard to the 3 spheres (star).

- **Type of risk:** Erosion / Marine Submersion Risk; Flooding Risk; Drought / Water Resource Risk; Heat Wave Risk; Seismic Risk; Multiple Risks.

- **N° and title of the recommendation:** numbering from 1 to n.

- **Aim:** what is the aim of the recommendation? What are the expected benefits? In first approach, 4 categories can be distinguished: improving knowledge (through the definition of further studies), decreasing vulnerability, preventing and minimizing risks, managing disasters (crisis and post-crisis situations). A recommendation may pursue several objectives.

- **Time period:** specify whether the recommendation concerns the current urban situation or the future urban development (2030 horizon).

- **Description:** as technical as possible and adapted to the local context. Reference is made to other related recommendations.

- **Constraints / difficulties:** constraints and limitations of the recommendation with respect to the geographical, technical, economical, social or political context; difficulties of technical, political, social or cultural nature, likely to affect the definition and/or implementation of the recommendation.

- **Uncertainties:** uncertainties regarding hazards, vulnerabilities, risks and related costs. Uncertainties regarding climate change. Uncertainties about reaching the aim of the recommendation. If uncertainties are considered excessive, it means that the recommendation must be combined with further studies and/or, for recommendations of « infrastructure / Technical measure » type, with appropriate strategies (no regret, reversible, low cost, safety margin …).
Concerned authorities and sectors: entities in charge of the recommendation implementation. Partnerships / collaborations to be established. Intervention sectors are recalled.

Monitoring and evaluation: after implementation of the recommendation, it will be necessary to assess its efficiency through appropriate indicators.

Cost: rough estimate in local currency. Cost bracket and, as far as possible, order of magnitude of annual maintenance costs.

Scheduling: three priority or urgency levels, related to scheduling horizons: very short term (within 2 years), short term (within 5 years), and medium term (10-15 years). The scheduling horizon depends on stakes, uncertainties about risk level and recommendation efficiency. Measures free of charge (regulatory, organizational, institutional measures …) can be scheduled in the short term.

Mapping: allows knowing if the related areas of risks are mapped.

Recommendation sheets are presented hereafter by type of risk:

- Multiple Risks
- Ground Instability, Seismic Risk
- Erosion and Marine Submersion Risk
- Flooding Risk
- Water Scarcity Risk

In each risk category, the sheets are then classified by sphere of intervention:

- Institutional Preparedness / Training / Awareness
- Urban Planning / Regulation
- Infrastructure / Technical Measure

It must be recalled that this classification is partly arbitrary, some of the recommendations encompassing the three intervention categories.

Areas of Greater Alexandria at risk are shown on the following map.
Légende

Vulnerabilities
- Very dense residential areas
- Dense residential areas
- Informal settlements and slums
- Industrial and commercial areas
- Planned urban expansion by 2030

Risks
- Subsidence on a long period (1982 - 2009)
- Subsidence on a short period (2003 - 2009)
- High erosion risks in 2010
- Medium erosion risks in 2030
- Flood prone areas (< mean sea level)
- High submergence risks
- Medium submergence risks
2. Multiple Risks Management

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deal with the current institutional context.</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

Other related sheets: 2, 20, 26

**Aim:**
Find solutions to improve technical co-ordination at the Ministerial and Governorate levels

**Synthetic background** (only impacting levels shown)

**Management of Major Risks (Government level):**
- IDSC – Information and Decision Support Center *(level: The Cabinet)*: co-ordinates Crisis and Emergency management actions, hosting the National Committee for Crisis Management and Disaster Risk Reduction (NCCMDRR) and the National Information management System (NIMS)
- General Administration of Civil Protection *(level: Ministry of the Interior)* enacts response plans to national disasters and trains personnel

**Management of Climate Change related Risks (Government level):**
- IDSC – Information and Decision Support Center *(level: The Cabinet)*: Since 2009, IDSC was committed by the Government to account for Climate Changes.
- MSEA – EEAA Egyptian Environmental Affairs Agency *(level: Ministry of State for the Environmental Affairs)*: enacts the Egypt’s Climate Change National Action Plan (ECCNAP), under the auspices of National Committee on Climate Change (NCCC), by means of a Climate Change Unit (EEAA-CCU)

**Technical and Scientific support (National level) by Autonomous Entities:**
- EMA *(Egyptian Meteorological Authority)*: Weather report and forecast, support to Civil Aviation, monitoring of Ozone and atmosphere pollutants
- NAARS *(National Authority for Remote Sensing and Space Sciences)*: Remote Sensing applications to agriculture, Hydrology, Land Use, Photogrammetry
- NRIAG-ENSN *(National Research Institute of Astronomy and Geophysics – Egyptian National Seismic Network)*: Seismology (national territory), Accelerometry (infrastructures)
At the regional (Governorate) level, the National System is duplicated as follows:

- **The Governor** (1) chairs the Governorate Civil Protection Unit, (2) follows the indications and enacts the decisions of IDSC and NCCMDRR in crisis management.
- **Alexandria Regional Branch Office of MSEA-EEAA**
- **Alexandria Branch of GOPP** (General Organization for Physical Planning - Ministry of Housing and Urban Development): coordinates the planning processes, monitors the plan implementation and the urban spreading

**Targets / recipients**: institutions above quoted.

**Expected benefits**: improved preparedness facing natural disasters and climate change issues.

**Scale**: national and regional.

### Raised Criticalities:

Although the overall system is provided with enhanced verticality – which presents the advantage of minimizing the number of independent collocutors – the following main criticalities are observed:

- **External, autonomous technical/scientific Authorities (NAARS, EMA) for Space and Meteorology**: both Authorities display acceptable technical background curricula, sufficient but not State-of-Art equipment, service provision levels of variable quality without turning into excellence. Science levels are overall poor. The overall image returned is also poor, with little evidence for effective support to Government choices.
- **External, autonomous scientific Institute NRIAS-ENSN (National seismic network)**: showing a sufficient technical background, average non-State-of-Art equipment, no real service provision, poor-to-sufficient Science levels. Apparently lacking in perspective view.
- **Technical information produced at Central levels is unevenly lacking in (i) completeness, (ii) homogeneity, (iii) timeliness, (iv) dissemination clearance between authorized levels.**
- **Regional Offices do not accede fully to, or do not interact timely with the information available at Central levels, giving rise to uncoordinated actions.**
- **The autonomous, external, technical/scientific Entities do not show synergetic, conclusive efficiency to assist in the Government’s territorial and crisis management, and should be differently framed**
- **The command-and-control chain is too long for minor-to-mild crises**
- **Center-to-Governorate Information flow is asymmetrical with respect to Governorate-to-Center**

The non exhaustive list of criticalities above may jeopardize, among others: (i), the capacity of giving timely information on minor-to-mild events that do not require the advice of NCCMDRR and NCCC, (ii) the capacity of responding and the effectiveness of response, (iii) the efficiency of the territorial control and the role of the Governor himself.
### Description

**Proposed actions to improve coordination:**

1) **Provide the IDSC with direct, univocal access to Integrated Geographic Information** (geophysical, cartographic, thematic - at the national scale and beyond), by:
   - **merging the three autonomous Entities** (Authorities EMA and NAARS; Institute NRIAS-ENSN) into one higher-ranked Agency, placed under the auspices of The Cabinet
   - **providing the new Agency with** (a) explicit functions of support to IDSC-NCCMDRR, with (b) service functions to MSEA-EEAA-NCCC in long-term CC risk management, and to (c) the Governorates in Emergency and Risk Management and Planning.
   - **split the professional careers in the new Agency in two separate levels - scientist and technologist** – or more.

2) **If 1) is implemented:** Clearly define the perimeters of NCCDMRR and NCCC in the new assets. Once defined, shorten as much as possible the command chain and have a ‘light’ NCCMDRR (for minor-to-mild crises or for long-lasting major crises)

3) **At the Governorate level:** (to solve raised criticalities) create a Unit at the governor’s Office, provided with exclusive, two-directional, unrestricted, full-clearance, real-time access to geographic data and the Integrated Geographic Information.

### Constraints / difficulties
- Institutional assets: merge two autonomous Authorities in an Agency, ‘higher’ located in a different institutional context.
- Withdraw one Scientific Institute from a non-service context, and place it as a third component in a new Agency provided with frontier tasks and dealing with high-level, high-technology services.
- Different criteria for career: negative perception may come from former Institute/Authorities employees.

### Uncertainties
- Where the Agency should be placed (proposed institutional location is: under The Cabinet, alongside with IDSC – to be verified).

<table>
<thead>
<tr>
<th>Concerned authorities and sectors</th>
<th>Monitoring and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorities in charge: all institutions above quoted.</td>
<td>Control and evaluation of the efficiency in real time situation (IDSC)</td>
</tr>
<tr>
<td>Sectors: institutional</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Scheduling</th>
<th>Joint mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merge - excepting physical relocation and new investments in equipment - should be at “zero cost”</td>
<td>Very short term (2 years)</td>
<td>No</td>
</tr>
</tbody>
</table>
2 – Strengthening the monitoring and early warning system

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present and future situation (horizon 2030) – this action is first and foremost aimed to protect the existing population.</td>
<td>Principal: Institutional</td>
</tr>
<tr>
<td>Other related sheets: 1, 3, 7, 8, 10, 13, 15, 18, 20</td>
<td>Secondary: Infrastructures (related to the need of improving and expanding networks of sensors, improving the quantitative information content, and promoting the circulation of the information flow)</td>
</tr>
</tbody>
</table>

Aim: Improve the System and its effectiveness

The success in natural risk mitigation is directly related to the knowledge of individual phenomena dealt with, and the capacity in quantitative forecast. Consequently, this statement points to the necessity of completing – where appropriate – and improving the performance of a national, multi-risk, monitoring and Early Warning system, in application to prevention, forecast and management of major risks and CC both at the Governorate and at the national scale.

Background

• Although it is stated that Early Warning systems on earthquakes, floods and air quality are in place, the Egyptian system of defense against natural and Man-made threats is significantly centered on operational response. This concept is widely known to present structural weakness (a) in fast impacting events, and (b) when the information chain is loose and/or the information-decision-command sequence is long. However, the choice of the defense system to put in place is long standing, remains out of the scopes of this analysis and is not to be discussed.

• As for the outreach of Early Warning information to the communities, conceptually arranged with a hierarchical information flow directed from center outwards, it was stated that a mechanism to enhance communication and enable exchange of relevant information has initiated.

Targets / recipients: institutions in charge of prevention and management of natural disasters and, beyond the institutional targets, all people likely to be affected by natural disasters.

Expected benefits: improvements in the management of emergency / crisis situations.

Scale: national.

Description: General policy

• It is suggested that top priority in the Information-and-Command chain be given to the real-time provision in sensor and data amounts, followed by progressive improvement of the data acquisition-transmission rates, and the inherent improvement in information flow of controlled quality.

• Once the quality fixed and the data rate established, it is suggested that the current policy based on Centre-driven alerts and crisis management, be associated to real-time involvement of peripheral Entities (Governorate). Involvement will be preferably based on real-time quantitative awareness of ongoing phenomena, through duplication of centrally pre-processed datasets at the local (Governorate) watch Units. See also Sheet 1.
• Improved awareness is expected to give rise to improved preparedness, leading the current response-based system to improve its overall performance. Suggested improvements apply to pre-crisis and early sin-crisis times (mostly out of the range of the full NCCDMRR) aimed to ease the decision and make minor events effectively manageable under the same policy without central, delayed input.

A) Adaptive improvement of monitoring arrays

1) Seismic. The areal density of sensors in the national seismic network to be significantly increased with respect to the current, nationwide average of 1 station per 20,000 km², aimed to detect and quantitatively characterize micro-earthquake activity heralding/accompanying active fault activity (see Sheet 10).
   • In consideration of location and stretch of active faults, suggested improvement is three-fold: equipment (retro-fitted or new), local sub-array area density, and real-time processing and dispatching. This will NOT provide forecast, but ensure control on ongoing seismic strain release.
   • Areal densities of sensors to be improved within the current aperture of the six subareas of Cairo, Hurghada, Burg-al-Arab, Kharga, Aswan and Toshka. Suggested factor of improvement is possibly larger than 3, having account for the ceiling of servicing and maintenance capacity.

2) Accelerometric. As GPA is the key-factor for seismic driven failure, it is suggested that distributed, real-time accelerometry on strategic buildings and infrastructures become the field of expansion of seismic related information.
   • It is suggested that instant-GPA information be transmitted to and exploited in real-time at a distant, central processing center, and stored and circulated care of the latter in support to decision making of responsible Entities, according to the general policy of relevant Authorities (CMDRS/IDSC and the NISC).

3) Rain- and Tide-gauges. It is suggested that the broad network of hydraulic sensors undergo same improvements as hypothesized above in A-2) and A-3). See also sheets 13, 18, 20.
   • Exchange of quantitative feedbacks (actors: EMA, EEAA and the Environmental Information System, NISC, IDSC) expected to improve rather than collapse following a suggested tenfold increase in quantitative information supply rates.

B) Quantitative emergency planning and synthetic scenario simulation

1) Geographical planning: valid both for short-term (Major Natural Hazards) and long-term (Climate Change related) hazards.
   • Suggested mid-term target is to keep listed (dynamically updated with suitable refresh frequency) and geographically located all available means in type, amount, state, efficiency percentage. Daily update of electronic database – to be replicated at the potentially involved superior level (preferably no more than one) is a standard. Information “pull or push” to be chosen on a case by case basis.
   • It is suggested that cartography and Information System standards to be fixed by one national Entity. Split over two national Entities (e.g. NISC / EIS) is possible / recommended provided to split between short-term and long-term hazards.

5 Ground Peak Acceleration
2) **Quantitative simulation of Impact scenarios**, valid for both short-term (Major Natural Hazards) and long-term (Climate Change related) hazards. Synthetic scenario drawing special attention in application to events and hazards for which effective prevention activity can be carried out, and mitigate future real damage scenarios. For Egypt, hydraulic applications deserve top priority.

- Straightforward application to fast- and slow-developing hydraulic scenarios as flash-floods, floods, sea level rise. Variable needs in resolution and precision of Digital Elevation Models (higher elevation resolution and precision are required for long-term events). Dealt with in this study.
- Dynamic tsunami scenarios – also dealt with in this study – including vulnerability classification of buildings and infrastructures (see Sheet 15).

### C) Institutional settings

- No modification in the Institutional settings is required (see Sheet 1).
- Communications should be two-directional as much as possible
- The existing, local watch units at the peripheral Entities should be equipped with the suitable, standard technologies for ensuring forth/back communication and exchange of quantitative information

### Constraints / difficulties

- Technically straightforward, provided that standard technology (consumer, as much as possible) is used
- Requires major training (also in terms of number of trainees) as distributes – partly – previously centralized functions

### Uncertainties

- No modification in the Institutional settings is required.

### Concerned authorities and sectors

- Authorities in charge: Information and Decision Support Centre, National Committee for Crisis Management and Disaster Risk Reduction, Civil Protection Administration (preparation and coordination), Governorates, Egyptian Environmental Affairs Agency (local coordination), Nanoelectronics Integrated Systems Center, Egyptian Meteorological Authority, National Authority for Remote Sensing and Space Sciences, Egyptian National Seismic Network (operators)
- Sectors: infrastructure, institutional, operational

### Monitoring and evaluation

- Control and evaluation of the efficiency in real time situation.

### Cost

- Networks of sensors and telecommunications (t.b.d. as a function of detailed inventory and maintenance impact on costs)

### Scheduling

- Short term (5 years) to mid-term (10 years)

### Joint Mapping

- No
## Preparation and self-protection against fast-impacting phenomena

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
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</thead>
<tbody>
<tr>
<td>Present and future situation (horizon 2030) – this action is first and foremost aimed to protect the existing population.</td>
<td>Strictly Institutional</td>
</tr>
</tbody>
</table>

Other related sheets: 2, 4, 5, 10, 13, 18, 20

### Aim:
Prepare and enable exposed populations to initiate and carry out timely, autogenous, self-protection and impact mitigation actions in advance on structured responses of Civil Defence/Civil Protection bodies or their equivalent. Training based on lessons learnt by frequently striking events (flash-floods, e.g.) and on synthetic scenarios for events characterized by low to very-low repetition rates (storm surges or even tsunamis, e.g.)

### Targets / recipients:
Population located in areas exposed to fast impacting phenomena (flash-floods, storm surges, tsunamis).

### Expected benefits:
Self-protection is the most effective way to save human life (the individual is the first author of its protection).

### Scale:
Regional

### Description
The proposed push for autogenous protection preparedness arises from the awareness that Public Safety services cannot ensure complete and/or timely protection anytime and at any place, in particular when fast striking natural risks (with little or no alert-to-impact delay) are involved. Actions referred to are supposed to allow acting on two levels:

- on one hand, it is a matter of preparing individuals and small groups (families, or limited groups of individuals) to naturally undertake the right self-protection action in situations of imminent danger, or of disaster event in progress;
- on the other, effectiveness of self-protection requires the development of a framework in which Public monitoring-and-forecast services may circulate the information about the current risk scenario and, doing this with appropriate timeliness, allow individuals undertaking the appropriate self-protection action timely.

With the notable exception of seismic disasters, whose impact mitigation cannot rely but upon passive protection - thus, on quality, strength and overall design of the building - risks presenting a non-negligible probability of hitting the Alexandria target look limited to:

1. **Extreme meteorological events, including windstorms and storm surges.** The forecast of such, relatively fast-striking events is perfectly in the reach of modern meteorology, provided that deployed technologies and systems assisting in the meteorological watch are efficient and adequate in area density/area coverage (see Sheet 18). In principle, this is the case of Alexandria vs. the central structure of the Egyptian Meteorological...
2. at a lesser level, tsunamis (1-hour delays between a shallow earthquake source within about 500 km, in Crete or Cyprus, and impact on the Egyptian shores). Notwithstanding the moderate hazard - only three major tsunamis are reported on the northern Egyptian shores, in the 17th Century BC and in 365 and 1303 AD - the risk is non negligible because of the combination of high vulnerability of the territory and a significant population density, with major seasonal inputs from Cairo (see Sheet 10). The efficiency of self-protection relies upon the following four conditions:

a) Preparedness of weaker (more exposed) categories of citizens, based on automated and well-addressed response to an official alert.

b) Preparedness to be based upon detailed escape and rescue emergency plans, foreseeing withdrawal of population (clustered in small, manageable groups) from exposed areas. Plans are expected to identify and map the shortest and simplest way-outs from every exposed area towards the nearest safe point, based on elevation. As near-flat areas do not offer natural perspective to discriminate slightly higher from slightly lower elevations, plans should be based on Digital Elevation Models imaged through appropriate technologies, to deploy in a preliminary stage while building preparedness. See also Sheet 20.

c) Availability of specific alert systems, and proved efficiency of the descending alert chain. Media of all types can be involved in the descending alert: however, on account of the type of risks dealt with, alerts would be better broadcasted on fast penetrating media. See also sheets 13 and 20.

d) Clear and immediately understandable markings (in all needed signs and languages) pointing to routes and places to reach, and not to leave until the alert is over.

Constraints and Difficulties

- Current systems should be open outwards, to broadcast alerts with the most likely short-term scenarios
- Type and content of information messages to be carefully weighted as their understanding is depending on an unlinear blend of human and cultural factors, including education
- System to be run permanently on 24h/24 shifts, after launch. System performances are expected to improve with time (with number of successful and missed alerts, leading to continuous adaptive tune-up of alert thresholds)
- Needs in high-precision/high-resolution 3-D digital cartography of the whole area (including DEM, buildings infrastructure and vegetation).
- 3-D digital cartography and its changes with time are appropriate for CC-triggered, sea level rise quantitative impact forecast (yearly to two-yearly towards the horizons of 2020 et 2030, if current expectations in sea level increase gradient are met)
- Small and large group exercises are recommended
- In lack of disaster events, there is a substantial risk of collapse of the interest/attention thresholds in the target populations. This holds specially true for infrequent events (tsunamis, e.g.)

Uncertainties

- Decisions on content, type and certification of alerts to broadcast
Concerned authorities and sectors

- Authorities in charge: Governorate (coordination), Egyptian Environmental Affairs Agency - Alexandria Regional Branch Office, with support of Red Crescent and other NGOs (operators)
- Sectors: institutional, operational

Monitoring and evaluation

Review of the alert thresholds at every missed alert; review of the system philosophy.

Cost

See Sheet 20

Scheduling

Launch: < 5 years

Joint mapping

No

4 – Future mechanism for natural risk insurance

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present and future situation (horizon 2030) – this action is first and foremost aimed to protect the existing population.</td>
<td>Institutional: Guaranteed by the State</td>
</tr>
<tr>
<td>Other related sheets: 3, 5, 6, 12, 15, 18, 24</td>
<td>Infrastructure: Concerning areas that (will) have already undergone structural and infrastructural improvement and securitization against Major (fast-impacting) and Climate Change related Natural Hazards</td>
</tr>
</tbody>
</table>

Aim

To contribute to sustainability and overall robustness of passive prevention measures to be taken against fast- and slow-impacting natural risks, by means of a hybrid Public/Private mechanism of mandatory risk insurance for individual, corporate and institutional customers.

Targets / recipients: all urban areas and populations likely to be affected by flooding or submersion risks.

Expected benefits: enable individuals and companies to be protected against economic consequences (material damages) of natural disasters.

Scale: national
Background:
operational examples worldwide of Institution-regulated insurance markets, and public insurance schemes
(compulsory or not) are found in:

- Caribbean Catastrophe Risk Insurance Facility (CCRIF) www.ccrif.org
- France (Caisse Centrale de Réassurance) www.cca.fr
- Indonesia (PRGBI - Earthquake Reinsurance Pool, P.T. Asuransi MAIPARK Indonesia)
- Japan (JER or “Jisai” - Earthquake Reinsurance Scheme) www.nihonjishin.co.jp
- MunichRe www.munichre.com
- Spain (Consorcio de Compensación de Seguros) www.consorseguros.es
- SwissRe www.swissre.com
- Taiwan (TRIEP - Residential Earthquake Insurance Program) www.treif.org.tw
- Turkey (TCIP - Catastrophe Insurance Pool) www.tcip.gov.tr
- United States of America (NFIP - National Flood Insurance Program of the Federal Emergency
  Management Agency) www.fema.gov/business/nfip/

Conversely, many Countries with high-to-very high levels of natural risk impact yearly (even Countries
provided with high industrial standards and highly developed insurance markets; Italy, e.g.) did not choose
adopting market- or State-regulated schemes for insurance protection against the impact of natural risks. In
some cases, indeed, the lack of adequately precise damage scenarios led to leave undefined the level of
involvement the financial implication of the Institutional reinsurer, thus leading to case-by-case, event-driven
interventions.

Description
Improved resilience to natural risks, obtained through special infrastructural artworks and structural mitigation
measures (see sheets 18 and 24), requires a mechanism for ensuring sustainable endurance. Among the
possible solutions, one is that of promoting for and – where appropriate – a natural risk insurance scheme for
individual, corporate and Institutional Entities in the sectors of the Governorate that have already undergone
resiliency improvements according to the scheme(s) proposed in this study.

In consideration of the central nature of the risk/emergency management structure in Egypt, a “hybrid”
insurance-and-reinsurance mechanism against natural, fast-impacting (earthquake and tsunami or storm
surge flooding) and slow-impacting risks (sea level change) can be explored. The hybrid mechanism foresees
damage compensation to be directly disbursed by insurance companies, whereas the State:
- issues declaratory statements of “natural disaster”
- decrees the compulsoriness of insurance against the natural risks quoted above, either in general (not
  recommended) or with restriction to the areas where infrastructural and structural mitigation measures,
  as those proposed in this study, have already been implemented (recommended)
- offers financial guarantees to reinsurer(s) and defines the range and type of insurance bonuses

The system, composed by a Guarantor (the State), a Reinsurer (public, private or a combination of two), and
the Insurer (from the – public or private – insurance company to the private broker) may develop over two,
en-échelon levels:
- Level-2 (Primary insurance). Relating to individual and corporate owners located in, or moving to sectors of
  the City/Governorate where risk mitigation structural works are completed and infrastructural measures
  already put into operation. Insurance policies are supposed to be taken out on areas and buildings that
  have been preliminarily secured against slow and fast impacting natural risks quoted above, through
  private brokers of private or public insurance companies.


• **Level-1 (Reinsurance)**, implying the insurance risk transfer from the insurance company to the third party (the reinsurer). The choice between public and private identity of the reinsurer, relies upon the political foundations of the reinsurance cover to be activated.

• **Level-1 loss refund**: in consideration of the current state of adaptation to climate change and major risk prevention measures in the area, the launch of an insurance and reinsurance mechanism could not be but partial and gradually extending.

• **Level-1 model**: In consideration of the availability of detailed impact scenarios – and in presence of State guarantees – the preferable business model is that of providing insurance cover only for a subset of major risks, e.g. those outlined above (“Catastrophe linked securitization”).

• **Level-1 mechanism**: In turn, having account for impact scenarios, long term sustainability looks better fit by an “excess of loss” refund mechanism (the reinsurer covers only the losses exceeding an assigned threshold) is thought to be preferable to “proportional” criteria (where the reinsurer receives a fraction of insurance bonuses and covers the corresponding fraction of damage).

### Constraints / Difficulties

- Level-1 and -2 insurance cover should be compulsory in those city/Governorate zones that have been re-qualified and made resilient to specific risks, aimed to reach the critical mass to make the mechanism effective and economically sustainable
- Restrictions apply as – in consideration of the severe heterogeneity of social and wealth layering in the Country – compulsory insurance against natural risks cannot be generalized.
- The implementation of a State-guaranteed insurance mechanism restricted to higher-standard buildings and infrastructures, would be discriminatory of unfavoured social classes
- An insurance market focused on natural risks shall not develop without establishment of State guarantees (among others)

### Uncertainties

- Level of the guarantee fund
- Involvement of international Re-insurers
- Long-term stability required for attracting international involvement in Level-1 and Level-2 action

### Concerned authorities and sectors

- Authorities in charge: Ministry of Finance (administrative supervision), Information and Decision Support Centre (coordination), Governorates (notification of natural disaster situation), operators to be determined …
- Sectors: institutional, operational

### Monitoring and evaluation

<table>
<thead>
<tr>
<th>Monitoring and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since the study phase</td>
</tr>
</tbody>
</table>

### Cost

- No associated cost
- Theoretically beneficial

### Scheduling

<table>
<thead>
<tr>
<th>Scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium term (&gt; 5 years)</td>
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</tbody>
</table>

### Joint mapping

<table>
<thead>
<tr>
<th>Joint mapping</th>
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</thead>
<tbody>
<tr>
<td>No</td>
</tr>
</tbody>
</table>
## 5 – Implementation of building and urban regulations

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mostly future situation (new urban projects).</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 3, 4, 6, 7, 8, 9</td>
<td></td>
</tr>
</tbody>
</table>

### Aim
To initiate the preparation and implementation of a set of mandatory requirements for local climate change policy to be incorporated within building and urban planning regulations and norms.

### Targets / recipients
all urban projects in natural disaster prone areas.

### Expected benefits
avoid exposure of new populations to natural disasters and climate change effects.

### Scale
national

### Description
The Unified Building and Planning Law in Egypt (Law 119/2008) and its By-laws now sets important standards regarding building regulations and urban planning requirements and processes. The National Government has now a crucial role to set mandatory requirements for local climate change policy. It is recommended that the Government steers a local climate protection action that leads to amending the Law, in particular through establishing norms and guidelines regarding strategic energy, transport and land-use planning.

The proposed norms and guidelines shall be in line with the climate change mitigation goals, and could comprise several focal issues regarding local mitigation and adaptation, including:

- Avoiding urban expansions in flood prone areas.
- Providing regulations regarding building and planning standards in areas prone to seismic risks.
- Efficient use of energy at the building (including public buildings) and urban levels, including establishing regulations regarding the use of heating/cooling devices, power-saving indoor and outdoor lighting systems, and promoting renewable energy solutions.
- Improving planning standards by incorporating strategic energy planning and energy efficiency requirements in zoning ordinance.
- Norms regarding improving public transport systems and promoting alternative forms of transport, such as walking and cycling.
- Establishing a waste policy and regulations, concentrating on waste prevention, reuse and recycling.
- Revising standards for new public buildings and residential buildings regarding provision of open and green spaces, energy conscious orientation and building materials (see Sheet 9).

In order to ensure the implementation of such regulations, two alternative approaches exist: first, a unit that is in charge of climate change policy can be established within the planning department at the Governorate level. Given the limited availability of staff, a second approach, which relies on a climate policy steering group, a climate protection co-ordination office or an overarching unit with appropriate competencies for mainstreaming climate change policy, appears to be more promising. This needs to be combined with various task forces from the local authority and academics that secure the implementation of the Law and co-ordinate the activities around specific issues and across all relevant policy areas within the Governorate administration.
### Constraints / difficulties
- Amending the Law is a time consuming process.
- Weak local mechanisms for monitoring and follow-up
- Some mitigation and adaptation measures are costly for the local authority to implement and needs a direct Governmental support

### Uncertainties
- Willingness of the Government to amend the new Law
- Low skills and staff limitations could impede the monitoring and follow-up of implementation.

### Concerned authorities and sectors
- Authorities in charge: Ministry of Local Development; Ministry of Housing, utilities and Urban Development; Ministry of Higher Education and Scientific Research (administrative supervision); Alexandria Governorate (implementation and enforcement).
- Sectors: urban planning, regulation, institutional

### Monitoring and evaluation
- Law amendment
- Local actions regarding policy implementation and follow-up

### Cost
- Law amendment: 2,500,000 EGP
- Local actions regarding policy implementation and follow-up: 12,000,000 EGP

### Scheduling
- Law amendment: till 2013
- Local actions regarding policy implementation and follow-up: till 2017

### Joint Mapping
- No
### 6 – Integration of Climate Change Adaptation and Mitigation Measures in an Urban Management Mechanism

<table>
<thead>
<tr>
<th>Time period</th>
<th>Mostly future situation (new urban projects). Other related sheets: 4, 5, 9, 11, 21, 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphere of intervention</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

#### Aim

To ensure the implementation of a city-wide urban management scheme that reflects proactive measures against possible climate change risks and threats. Specific objectives are to:

- Incorporate different mitigation measures within the Alexandria Strategic Urban Plan (SUP) currently being prepared by the General Organization for Physical Planning.
- Develop a sound efficient urban management framework that includes an information system, a monitoring and evaluation process and an adaptation mechanism for urban growth in relation to the sea level rise and climatic change effects.
- Conduct capacity building programs for local authority and urban managers.

#### Targets / recipients

Local authorities and urban managers.

#### Expected benefits

Avoid exposure of new populations to natural disasters and climate change effects.

#### Scale

Regional.

#### Description

The Local authority in Alexandria has a major role in the area of climatic change policy implementation, through its planning and environmental protection departments.

Meanwhile, the General Organization for Physical Planning (GOPP) and the United Nations Development Programme (UNDP) are implementing a Project for the preparation of a strategic urban plan (SUP) and an urban management mechanism for the City of Alexandria. The Local Authority is the major player in the plan formulation and in the realization of a city-wide participatory approach. In this respect, both the SUP and the urban management mechanism could serve as a vehicle for adopting climate change policies and guidelines.

The SUP is a tool for directing future growth, defining city limits, and articulating a land use scheme that delimits regulations for densities, building heights and open space ratios. The implication of climate change on the urban fabric should be considered in the work process, ensuring the adoption of mitigation and adaptation measures in the final plan.

Furthermore, in order to ensure a sustainable long-term city development and an SUP implementation, a sound efficient management framework is needed. Both GOPP and UNDP are currently working on formulating a city management framework that includes a capital investment plan, a private-public, business and economic forums to exchange management know-how and experience, a developed information systems for city management, and a community-based M&E system. It is also proposed to complement this initiative by the inclusion of essential urban management components such as sustainable infrastructure and services development, a management strategy responsive to the threats from the possible sea level rise and its disastrous effects on the City, amelioration of the urban environment, and protection of the cultural heritage.

The proper coordination between those initiatives could enhance city preparedness to disasters, and
strengthen linkages and synergies between climate policy and sustainable development.

**Constraints / difficulties**

- Urban management needs a more comprehensive understanding from the local authority and decision makers of the importance of long term planning regarding climatic change.
- Land and building values imposes challenges regarding decreasing urban densities and directing urban growth.
- Conflicts in land legal ownership and registry impose a major challenge in directing and controlling urban growth.

**Uncertainties**

- Ability of the local authority to properly supervise the implementation of SUP
- Availability of trained and permanent staff for implementing climate change adaptation measures within an urban management framework.

**Concerned authorities and sectors**

- Authorities in charge: Alexandria Governorate (Planning Department, Planning and Follow-up Department); General Organization for Physical Planning – Regional Center.
- Sectors: construction, urban planning, regulation, institutional

**Monitoring and evaluation**

Achievement of the SUP and management scheme

<table>
<thead>
<tr>
<th>Cost</th>
<th>Scheduling</th>
<th>Joint Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,000,000 EGP</td>
<td>• Preparation of SUP by 2012</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>• Implementation of an urban management scheme by 2022</td>
<td></td>
</tr>
</tbody>
</table>

**7 – Proactive measures for protecting the urban population prone to natural disasters: Abu Quir Area**

**Time period**
Concerns first the protection of the present population, but also future urban developments.

Other related sheets: 2, 5, 8, 12, 19, 23, 24, 25

**Sphere of intervention**
There are seven possibilities in accordance with the possible overlaps (see position of the star)
### Aim

The purpose of this action is to shift the emphasis of the disaster management from post-disaster response to pre-disaster proactive actions involving preparedness and prevention. In Alexandria, one of the expected highly vulnerable zones to flooding and submersion is the Abu Quir Area. The main aim is to propose and implement a long term pro-poor protection plan for the population of Abu Quir against flooding and submersion risks.

**Targets / recipients:** vulnerable population of the Abu Quir Area.

**Expected benefits:** protection of this population against flooding, storm surges and tsunamis, taking CC into account.

**Scale:** local.

### Description

Abu Quir area is located in the far east of Alexandria City within the 1.2 Million inhabitant District of Montazah. The urban population in Abu Quir could experience very shortly the negative impacts of climate change, and future projections suggest that these impacts could get worse. In this regard, the undertaken risk assessment and vulnerability analysis of the urban Alexandria revealed a high flooding and submersion risk in this area. The largest impact will be on poor communities that currently suffer from very dense agglomerations (larger than 1000 persons/acre) and living in a deteriorated built environment. The proposed intervention methodology is based on a framework which:

(a) Analyzes the present situation on a household level, both in terms of the local community **vulnerability to flooding and submersion events**, as well as their sources of resilience for dealing with the negative impacts of the climate change (see sheets 19 and 24). The analysis will include preparing a database of the current situation regarding land use and value, building conditions, densities and major activities. This database will assist in formulating an overall view of the physical, financial, natural, human and social capital of the area.

(b) Prepares a **zone (territorial) map** that delimits and classifies the area based on the level of threat and intervention type to build resilience. The map will define priorities amongst the most vulnerable areas and buildings. The interventions could include (see also **Box 1**):

- Reducing the population density of the vulnerable urban fabrics. This reduction could be achieved through the preparation of a detailed long term plan, and a regulatory process that controls building heights and open space allocation.
- Designating buffer natural spaces along the shoreline, acting as protection zones along and ensuring the relative retreat of urban population away from the seafront.
- Population displacement in highly threatened areas, especially those related to poor neighborhoods with deteriorated building conditions and urban planning norms.
- Defining strategies for the protection and conservation of the area’s cultural assets and valuable heritage landmarks.
- Implementing a long term plan for the gradual regularization of the urban areas, including replacement of selected buildings with open spaces, widening streets, and improving road network to incorporate additional exits and entrances to the area.
- Constructing appropriate means for defense against sea level rise and flooding, such as barriers, breakwaters, coastal armoring and seawalls. Elevated development could also be incorporated within the defense plan.

(c) Establishes a **monitoring unit** that measures the sea level rise rates and updates the intervention priorities. The unit shall include an early warning system, an emergency response and evacuation plan, public information and awareness strategy, institutional coordination (see Sheet 2).

(d) Creates **appropriate legislation and planning regulations** specific to the Abu Quir Area, by which the implementation of disaster resistant measures in buildings and structures could be made mandatory. Appropriate land use zoning taking into account the vulnerability of hazard prone areas is
one of the important components for reducing damage in future disasters. It is recommended to establish an appropriate techno-legal mechanism at the local level for safer constructions in Abu Quir and also for retrofitting of existing housing stocks in vulnerable areas.

The successful implementation of an intervention scheme in Abu Quir area will require a serious and prompt action from the local authority in order to designate the area as a ‘special zone’ which has its own flood and submersion management plan and regulations. A special Unit or taskforce at the level of the Housing Directorate will be an important tool that could ensure the implementation of the proposed long term intervention framework.

**Constraints / difficulties**
- Implementing an urban regularization framework in a highly dense area is a challenge that could create resistance at the community level.
- Due to the large population in Abu Quir, the displacement and regularization plans will entail large budgets that are beyond the local capacities.

**Uncertainties**
- Ability of the local authority to properly supervise the implementation of an intervention framework.
- Long term risks are usually undervalued by the local authority and community, and no action will be taken unless pushed by the National Government.

**Concerned authorities and sectors**
- Sectors: infrastructure, urban planning, regulation, institutional

**Cost**
- Unit Establishment 2,400,000 EGP
- Preparation of the intervention framework 16,000,000 EGP
- Implementation of the framework 2.5 to 10 Billion EGP.

**Monitoring and evaluation**
- Achievement of the various steps (see scheduling).

**Scheduling**
- Establishment of a Unit or taskforce for managing the Area by 2012.
- Designating Abu Quir as a special vulnerable area by 2012.
- Preparation of the intervention framework by 2017.
- Implementation of the framework (urban regularization, displacement, etc… by 2032)

**Joint Mapping**
- Flood and submersion risks
Box 1: Risk Prevention Plans

The development of Risk Prevention Plans (RPP) is a necessity, and sometimes a priority, for the regulation of urban development, especially in areas where demographic pressure is strong. RPPs must:

- be developed on the basis of a qualitative approach encompassing whole areas potentially affected by a hazard, allowing an over-arching approach to hazards at a multi-municipal level;
- cover the fields of urban planning, construction, land use and public safety;
- propose measures that are appropriate to the level of risk and proportionate to the risk prevention aim;
- be conducted with full transparency, seeking collaboration that is as wide as possible with all relevant local stakeholders, especially elected representatives.

RPPs may address a single natural hazard or several (multi-hazard RPPs). Below, we illustrate the approach with reference to Coastal RPPs.

Coastal zones are typically flat, low-altitude areas that are particularly vulnerable to marine flooding. They are also often areas where the shoreline is retreating rapidly. As is the case elsewhere, these are areas that are very much in demand and urbanisation is proceeding apace. The phenomena of erosion and flooding can therefore entail a high level of risk. Two examples of development of RPPs are presented below: in Languedoc Roussillon and at Grâves, in the Lorient region (France).

A first step was to establish the reference hazard level (for 100 year return period) to be considered when preparing the marine flooding RPP; it was taken as +2 m NGF (French ordnance datum).

Subsequently, the depth of flooding of the natural terrain for the reference hazard was established:

- in the surge zone: the hazard is always considered to be high in the surge zone, regardless of the depth of flooding,
- in the flooding area beyond the surge zone: the hazard is classified in accordance with this depth in relation to the natural terrain.

In Languedoc Roussillon, a threshold of 50 cm has been adopted for the high flooding hazard, it being understood that the high hazard corresponds to the level of water above the natural terrain, beyond which the risk is judged to be too great to authorise building.

<table>
<thead>
<tr>
<th>Natural terrain level</th>
<th>Depth of water (D) for reference hazard</th>
<th>Hazard classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surge</td>
<td>Z &lt; 3m NGF</td>
<td>H &gt; 0 m</td>
</tr>
<tr>
<td>Flooding beyond surge</td>
<td>Z &lt; 1.5 m NGF</td>
<td>H &lt; 0.5 m</td>
</tr>
<tr>
<td></td>
<td>1.5m NGF &lt; Z &lt; 2m NGF</td>
<td></td>
</tr>
</tbody>
</table>

Depending on the risk objects, which are slightly or non-urbanised areas, lidos and urbanised areas, and by cross-referring them with hazard levels, a level of risk was estimated and areas where restrictions should apply were determined, useful for regulatory zoning (see table below).
Urban planning regulations could then be formulated.

Approved by the government on 6 January 2011, the RPP for the village of Grâves (2 km², 100 habitants), located at the entrance to the port of Lorient (France), is an example of current flood prevention policy.

Successive failures of dikes during storms (2001 and 2008), causing severe flooding (depth of 3 metres) of around a hundred houses led the government to take steps to incorporate the notion of risk into urban planning policy.

The Risk Prevention Plan of the Gâvres Municipality

The prevention plan led to classification of three types of sensitive areas in the municipality of Grâves (see figure above). Given the existing urban development and the narrow strip nature of the municipality, the scope of these restrictions is limited. But they do set out a regulatory framework and establish a method that may be useful elsewhere.

Developed after a process of wide collaboration, the prevention plan is a regulatory tool for urban planning that confers legal rights and obligations.
8 – Proactive measures for protecting the urban zones prone to natural disasters: El Max Area

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerns first the protection of the present population, but also future urban developments.</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 2, 5, 7, 12, 18, 23, 24, 25</td>
<td></td>
</tr>
</tbody>
</table>

**Aim**

The purpose of this action is to shift the emphasis of the disaster management from post-disaster response to pre-disaster proactive actions involving preparedness and prevention. In Alexandria, one of the expected highly vulnerable zones to flooding and submersion is ElMax Area. The main aim is to propose and implement a long term protection plan for the industrial and commercial settings of ElMax against flooding and submersion risks.

**Targets / recipients:** vulnerable population of the El Max Area.

**Expected benefits:** protection of this population against flooding, storm surges and tsunamis, taking CC into account.

**Scale:** local.

**Description**

ElMax area is located west of the city center and the main Alexandria Port. The area is characterized by the presence of several warehouses, silos, a football stadium and industrial sites. The area is adjacent to important petrochemical premises. Meanwhile, the pumps on ElOmoum Canal of ElMax are playing a crucial role to keep the balance between the water level in Lake Maryut and the Mediterranean sea. Whilst it is located in a highly populated area including about 600,000 inhabitants in Gharb and Agamy Districts, the area population does not exceed 10000 inhabitants.

ElMax area could experience very shortly the negative impacts of climate change, and future projections suggest that these impacts could get worse. In this regard, the undertaken risk assessment and vulnerability analysis of the urban Alexandria revealed a high flooding and submersion risk in this area. The largest impact will be on the industrial and commercial settings that present a National asset and plays in important role in the city economy.

It is worth mentioning that the port authority is considering the expansion of its activities by constructing an intermediate port between Alexandria Port and Dekheila Port. Such project – if implemented - could have a future impact on the protection of the shoreline at ElMax.

The proposed intervention methodology is based on a framework which:

1. Analyzes the present situation both in terms of the local activities vulnerability to flooding and submersion events, as well as their sources of resilience for dealing with the negative impacts of the climate change (see sheets 18 and 24). The analysis will include preparing a database of the current situation regarding land use and value, building conditions, densities and major activities. This database will assist in formulating an overall view of the physical, financial, natural, human and social capital of the area.

2. Prepares a zone (territorial) map that delimits and classifies the area based on the level of threat and intervention type to build resilience. The map will define priorities amongst the most vulnerable areas and buildings. The interventions could include:
• Reducing the economic (commercial, transportation, industrial) activities of the vulnerable urban fabrics. This reduction could be achieved through the preparation of a detailed long term plan, and a regulatory process that control building and open space allocation.

• Designating buffer natural spaces along the shoreline, acting as protection zones along and ensuring the relative retreat of urban population away from the seafront.

• Population and activity displacement in highly threatened areas, especially the areas that exhibits deteriorated building conditions and low urban planning norms.

• Defining strategies for the protection and conservation of the area’s cultural assets and valuable economic premises.

• Implementing a long term plan for the gradual regularization of the areas, including replacement of selected buildings with open spaces, widening streets, and improving road and tram networks.

• Constructing appropriate means for defense against sea level rise and flooding, such as barriers, breakwaters, coastal armoring and seawalls. Elevated development could also be incorporated within the defense plan. The future plan for the Port expansion should also be considered.

(g) Establishes a monitoring unit that measures the sea level rise rates and updates the intervention priorities. The unit shall include an early warning system, an emergency response and evacuation plan, public information and awareness strategy, institutional coordination (see Sheet 2).

(h) Creates appropriate legislation and planning regulations specific to EIMax Area, by which the implementation of disaster resistant measures in buildings and structures could be made mandatory. Appropriate land use zoning taking into account the vulnerability of hazard prone areas is one of the important components for reducing damage in future disasters. It is recommended to establish an appropriate techno-legal mechanism at the local level for safer constructions in EIMax and also for retrofitting of existing housing stocks in vulnerable areas.

The successful implementation of an intervention scheme in EIMax area will require a serious and prompt action from the local authority in order to designate the area as a ‘special zone’ which has its own flood and submersion management plan and regulations. A special Unit or taskforce at the level of the Housing Directorate will be an important tool that could ensure the implementation of the proposed long term intervention framework.

Constraints / difficulties
• Implementing a regularization framework in a highly dense economic area is a challenge that could create resistance at the community level.
• Due to the important economical settings in EIMax, the displacement and regularization plans will entail large budgets that are beyond the local capacities.

Uncertainties
• Ability of the local authority to properly supervise the implementation of an intervention framework.
• Long term risks are usually undervalued by the local authority and community, and no action will be taken unless pushed by the National Government.
### Concerned authorities and sectors
- Sectors: infrastructure, urban planning, regulation, institutional

### Monitoring and evaluation
Achievement of the various steps (see scheduling).

### Cost
- Unit Establishment 2,500,000 EGP
- Preparation of the intervention framework 16,000,000 EGP
- Implementation of the framework 800 M EGP to 4 Billion EGP.

### Scheduling
- Establishment of a Unit or taskforce for managing the Area by 2012.
- Designating ELMax as a special vulnerable area by 2012.
- Preparation of the intervention framework by 2017.
- Implementation of the framework (urban regularization, displacement, etc… by 2032)

### Joint Mapping
Flood and submersion risks

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**9 – Piloting a climate change risk sensitive urban plan for a new expansion area in the city of Alexandria**

**Time period**
- Future urban developments until 2030.
- Other related sheets: 5, 6

**Sphere of intervention**
- There are seven possibilities in accordance with the possible overlaps (see position of the star)
Aim

The aim of this action plan is to promote adaptation to and control of climate change in urban planning of new city expansions, especially those areas susceptible to flood and seismic risks. The action is not limited only to vulnerable areas but could also be implemented as a best practice in other city expansions and new settlements, through investigating three main themes: urban form, lifestyles and energy sources. The specific objectives are:

- To prepare guidelines for urban planning in the expansion areas that are environmentally conscious to possible risks from climate change. The guidelines shall include recommendations regarding urban form, lifestyles and energy sources.
- To implement a pilot plan in the new expansion areas delimited in the Alexandria new Planning Boundary.
- To implement an open space strategy that includes green and blue networks
- To discourage residential development on highly vulnerable lands.
- To replicate the pilot study in other urban areas and new settlements (e.g. New Alamein City)

Targets / recipients: new city expansions.

Expected benefits: prevent exposure of new populations to flooding, storm surges and tsunamis, taking CC into account.

Scale: regional.

Description

Scientific opinion is now unanimous that global temperatures are likely to continue to rise with concomitant extreme weather patterns and events. The results of the current study revealed that the global warming and climate change will have a devastating effects on the urban living of Alexandria in every respect from ‘heat islands’, sea level changes, increased seismic activities, as well as severe droughts and floods paralyzing urban areas. However there is an opportunity to be prepared for such changes through selecting appropriate urban planning schemes for the new expansion areas, reflected in buildings, street and community design for a more environmentally sustainable city.

A new urban city boundary has now been prepared, including new open spaces towards the south and the west. Those areas are all prone to flooding risks and could also be transformed into urban sprawls if not adequately planned. The proposed action will select a priority area for development and prepare guidelines and a framework for implementation. The pilot project will set the standards for the new urban development that adapts to the expected climate changes and mitigates the flooding and seismic risks. The realization of this action will include the following steps (see also Sheet 6):

- **Formulating guidelines for the preparation of urban plans in susceptible areas:** the guidelines will include recommendations and best practice in three main themes – urban form, lifestyles and energy sources. The recommendations will be oriented towards achieving a better living environment that alleviates the negative effects of the potential warmer and drier climate, flooding problems and seismic activities (see Boxes 1 and 3).
  - The urban form will include recommendations on the built up densities and open spaces, creation of green and blue natural networks, energy efficient urban pattern, seismic resistant structures, and prescriptions for bioclimatic buildings.
  - The lifestyles, in particular the way in which people commute, will include recommendations regarding means to reduce urban emissions and heat islands, new and sustainable transportation modes, encouraging pedestrian movement, more sustainable water consumption habits and the way people heat and cool their buildings.
  - Energy sources will define the mode of energy production that produces less waste. Meanwhile alternative energy sources will be proposed, including using of solid wastes and envisioning a neighborhood sustainable waste collection and recycling.

- **Selecting a pilot area and preparing a detailed urban plan:** the selection of the pilot area will be based on the development priorities set by the Governorate Planning Department, and the Strategic Urban Plan of Alexandria till 2032. A special emphasis will be on those areas that are newly included in the Urban...
Boundary and prone to unorganized urban development. The detailed action urban plan will include:

- Provision of public transport and infrastructure for alternative forms of transport logistics
- Waste service provision Installations for recycling, composting and “waste to energy” facilities
- Recycling, composting and reuse schemes
- High energy-efficiency standards in new public buildings
- Land use: compact growth, infill, mixed use
- Mobility and walkable streets
- Conservation, green buildings
- Infrastructure – alternative energy
- Public outreach and involvement

The implementation of the pilot project will depend on the support of the planning authorities (Governorate planning department and the General Organization for Physical Planning). It will require sufficient government fiscal capacity to finance urban facilities and infrastructure and a unitary control of planning of land development, or closely coordinated control. The pilot case study could be easily replicated in other city areas, including new expansions towards the west (Burg ElArab city), as well as the proposals for new settlements (e.g. New Alamein City), ensuring the implementation of the sustainable urban development of the Region.

Constraints / difficulties

- Some mitigation and adaptation measures are costly for the local authority to implement and needs a direct Governmental support
- Conflicts in land legal ownership and registry impose a major challenge in directing and controlling urban growth and allocating land for future development.
- The rise of land value as a result of the pressing demand on expansion.
- The way “best practices” can be tested and the criteria of success for the urban planning scheme are difficult to establish.

Uncertainties

- Ability of the local authority to properly supervise the implementation of SUP
- Availability of trained and permanent staff for implementing climate change adaptation measures within an urban management framework.

Concerned authorities and sectors

- Authorities in charge: Alexandria Governorate, Planning Department, General Survey Authority (coordination); General Organization for Physical Planning – Regional Center, Egyptian Environmental Affairs Agency – Alexandria (operators).
- Sectors: urban planning

Monitoring and evaluation

Achievement of the various steps (see scheduling).

Cost

Formulation of Guidelines: 2,500,000 EGP
Selection of pilot area and prepare detailed and action plan: : 4,000,000 EGP
Implementing the urban plan by 2017: 3 Billion EGP

Scheduling

Formulation of Guidelines by 2013
Selection of pilot area and prepare detailed and action plan by 2014
Implementing the urban plan by 2017

Joint Mapping

Flood, submersion, erosion and subsidence risks
Box 2: New risk-adapted and attractive urban forms

Changes in lifestyle imply a more flexible approach to housing. **Creativity in urban forms is one of the new challenges of intensification.** The scalability of housing and the qualitative treatment of open public and private spaces are to be taken into account from the design stage. Several factors linked to the urban form have an effect on the perception of density:

- Diversity of architecture by varying the levels of density and improving perception.
- The public space frame and its quality play a major role.
- Open, transparent and pervious spaces are important.
- Individual-access housing, responding to individual housing aspirations in a collective form, also plays a role.

**Promote individual-access housing**

Inhabitants should benefit from a private outdoor space, whether it is a terrace or garden, and which is of comparable size to a comfortable room. Several combinations are possible which allow for the urban environment to be enhanced.

**Create dense individual housing**

The dream of having a house, the need for private space, the assertion of ownership and the achievement of social success should result in new forms of individual housing which consume less space. It is possible to propose dense housing, presenting the charms of being close to facilities and services, whilst maintaining everyone’s desire for privacy and self-sufficiency.

**Find answers that are suited to welcoming mixed activities**

Answers exist which offer a wide range of urban densities to welcome the tertiary sector. However, innovative answers which allow for densification and the maintaining of mixed activities in cities still need to be found, in particular for small companies.
Diversity between collective and individual housing

Combine density and privacy: Operation “le Bois habité” (inhabited wood) in Lille, France

The programme involves constructing a mixed district, punctuated with green spaces, and comprising convenient facilities, large-scale facilities, offices, housing and hotels. With over 600 houses planned, the so-called “inhabited wood” sector displayed high density objectives (92 houses/ha) whilst maintaining the privacy of each house.

The concept is innovative: a planted environment in which reduced-height buildings are spread out and which have varying typologies: townhouse-type individual houses; houses with individual access; small shared housing, etc.

This organisation combines high density with individual housing and associates site revegetation, major infrastructure and city-centre functions. The quality of the architecture and housing, as well as the environmental proposals, prevailed in the allocation of lots.

Overall view of the “inhabited wood” district

Housing blocks

These new forms of urban planning allow for natural risks to be better managed, in particular flood risks and heat waves.
Box 3: Balance between open space and built-up areas

The success of an urban intensification project requires a balance between the density of the built-up area and the quality of the public spaces. This not only concerns charm and quality of life, but also protection from natural risks (floods, heat waves, etc.).

☞ Think of public spaces at the conurbation level

A very large-scale discussion should allow for the main development principles which improve the use of and promote using public spaces to be defined. This discussion implies collective work between officials, inhabitants and the various stakeholders at the time of the project, and allows for the management of said spaces to be facilitated. Moreover, the homogeneity of treatment is a way of affirming the identity of a conurbation and increasing its attractiveness.

☞ Encourage urban renewal by requalification

Requalification of public spaces covers different operations: redevelopment of a public square, restructuring and development of streets, requalification of an urban park in relation to its environment, residentialisation projects, etc.

☞ Favour multiple uses

In the framework of intensification, a public space should be designed to welcome various uses – a place for moving around, resting, leisure activities, meetings, and long-term or temporary activities – and to be organised differently during the day and at night, during the week and at the weekend.

☞ Take advantage of density to create public spaces

Choosing densification of built-up areas may allow for greater surface areas to be cleared for public spaces and financing corresponding to quality treatment to be obtained through real estate programmes.
### 3. Management of Ground Instability / Seismicity

#### 10 – Develop the earthquake recording and surveillance system

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerns both current urban situation (enables improving anticipation and management of seismic risks) and future urban development (2030 horizon)</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 2, 3</td>
<td></td>
</tr>
</tbody>
</table>

**Aim**

Improve knowledge on the response of seismic motion sites, a necessary component in setting up a warning system.

**Targets / recipients:** authorities in charge of prevention and management of seismic risks.

**Expected benefits:** improve early warning to reduce seismic consequences.

**Scale:** national.

**Description**

The waves emitted by earthquakes may be detected by measurement apparatus which record ground movements. And yet, any earthquake which has not been recorded, or in very little detail, constitutes a valuable loss for knowledge on the regional seismicity. It would be desirable to **make the present system denser in order to obtain more reliable characteristics** (coordinates of the focus, magnitude, focus mechanism, etc.) of the earthquakes, with apparatus such as seismometers and accelerometers. The quality of this information would thus allow for improved knowledge on the local and regional risk in the medium term.

A research team that is responsible for tracking the latest technological developments in the field of international earthquake surveillance and tracking **country experiences** in this field to determine areas of success and threats that have faced their surveillance systems, is necessary to develop the most suitable surveillance system for Egypt.

Moreover, within this framework, it would be necessary to move towards international research teams, at present focused on the development of an **early earthquake warning system** (see also Sheet 2).

**Constraints/difficulties**

Have a team of seismologists (technician, engineer, doctor, etc.) which is capable of managing an earthquake recording system and analysing the signals.

**Uncertainties**

- Current situation regarding the earthquake recording and surveillance system in Egypt
- Efficient channeling of data to all the relevant country systems that facilitate fast response to immediate or urgent earthquake detections
### Concerned authorities and sectors

- Authorities in charge: Egyptian National Seismic Network, Information and Decision Support Centre (operators); Governorates (recipients).
- Sectors: study, technical measure, institutional

### Monitoring and evaluation

| Number and density of seismometers and accelerometers |

### Cost

| Cost | 2.4-3 million EGP for the whole system + 1.2-2.4 million EGP/year for maintenance and operation (labour cost included) |

### Scheduling

| Scheduling | Short term (< 5 years) |

### Joint mapping

| Joint mapping | No |

### 11 – Carry out seismic microzoning on Alexandria and take it into account in the urban development plans

#### Time period

Concerns both current urban situation (enables risk identification for existing buildings) and future urban development (enables risk integration in urban development projects).

Other related sheets: 6, 12

#### Sphere of intervention

There are seven possibilities in accordance with the possible overlaps (see position of the star)

#### Aim

Locate the areas where the site effects (direct or indirect) may occur, taking them into account in the calculation of response spectra and the local development plans.

#### Targets / recipients

mostly around lake Maryut and Gharb - Al-Montaza - Sharq districts.

#### Expected benefits

avoid building collapse and related deaths and casualties.

#### Scale

regional.

#### Description

In accordance with the local topographical and geological conditions, there may be: 1) notable modifications in the seismic motion, we thus speak of “site effects”; 2) effects brought about by the earthquake, such as landslides, tsunamis, liquefaction, etc. Therefore, for an identical type of building, the effects of an earthquake could be more or less destructive depending on the location, even only a few tens of metres away.

This is why, in addition to the definition of the reference seismic motions indicated in the regional seismic zoning (so-called seismic motion “on the rock”), local studies must be carried out to identify and characterise these possible effects. This is seismic microzoning (see Box 4).

The necessary investigations may be more or less complex in accordance with the geographical and geological situation. The sophistication of the investigations will be conditioned furthermore by the methods given (possibly set in accordance with the level of risk and/or stakes).

Regarding the site effects, it is important to differentiate the amplification effects connected to the topographical configuration from those connected to the geometrical type and characteristics of the surface-level or below-surface-level formations.

Regarding the topographical site effects, the mounds, cliff edges, crests, etc. should be located. The reflection of seismic waves inside these reliefs can amplify the tremors that reach them. Buildings constructed on these types of relief could be subjected to greater seismic effects than on a neighbouring site with no raised ground if the ground and building frequencies concord. If it is not possible to change the location, the necessary
architectural measures should be taken (for example, modification of the building’s natural frequency if the hill’s response spectrum has been established) and/or the appropriate construction measures (increased mechanical resistance, insulators, shock absorbers, etc.). Nevertheless, it should be noted that given the topographical situation of the Alexandria region, the main site effects will, in particular, be sedimentary.

Concerning the effects connected to the subsoil type and geometry, it will be necessary to conduct studies to characterise the thickness of the surface layers, their depth, and their geometrical and mechanical characteristics. The purpose of the analysis of geological layers is to calculate the “response spectrum”. It is using this information that the architect and the structural engineer can evaluate the vulnerability of these buildings or infrastructure and calculate the natural seismic effect on the ground-structure relationship.

Regarding indirect effects, the areas likely to be destabilised by seismic effects should be identified (rock fall, landslides, subsidence, etc.), as well as soil liquefaction. A landslide map should be established (departure areas, propagation, reception, etc.). It should indicate the type of landslide that has been forecast and provide an estimate of its intensity (geometry). As far as possible, it would not be recommended to build on areas which are in theory unstable or located in a propagation-accumulation area. Failing this, recommendations adapted to the type and intensity of the phenomena, as well as the local geological and hydrogeological situation, should be established (drainage, building foundations, purging, stabilisation, etc.). Concerning the territory of Alexandria, however, this risk of indirect site effects seems negligible.

The map of liquefiable or potentially liquefiable areas should take into account the reconnaissance surveys conducted within the framework of the direct effects study and may include new on-site and/or laboratory reconnaissance surveys. Soil liquefaction is the total destruction of soil during a few seconds. In the case of seismic vibrations, under the effect of waves, the interstitial water pressure of the granular soils increases and makes them lose their cohesion. In order to take this site effect into consideration, based on geological and geotechnical data, the below-surface-level formations (less than a few tens of metres deep) likely to contain non-coherent sand or silt layers and small grains (0.05 to 2mm) should thus be identified. If another location cannot be selected to construct the buildings, several aspects should be observed, for example, the depth of the foundations, the type of foundation, treating the soil to give it the desired characteristics, etc.

As for the region of Alexandria, it is particularly recommended to watch out for lands situated in low areas and comprising quaternary formations, which are not very coherent, with, as a priority, those indicated as unstable in the interferometry study Atamira report, 2010)

Constraints/difficulties
- Difficulties to carry out geological and geotechnical investigations in urban area
- The need to develop the maps on a very short term and continually follow up any geological changes that might occur over the time span till 2030

Uncertainties
Probability of a significant seismic to occur.

Concerned authorities and sectors
- Sectors: urban planning, institutional

Monitoring and evaluation
- Completion of the seismic micro-zoning.
- Incorporation in the Alexandria Urban Master Plan and urban planning regulation.

Cost
- 2 400 000 EGP to 3 000 000 EGP for the seismic micro-zoning (landslide risks and liquefiable areas included), depending on the existing knowledge on the basement (thickness, type of soil) and the need for in situ investigations

Scheduling
- Very short term (< 2 years)

Joint mapping
- Subsiding areas located by interferometry
Box 4: Seismic microzoning

The local seismic hazard study determines the way in which the study area would respond if it were subjected to a reference seismic motion. This includes the modification of the response spectrum due to local site conditions (lithological site effects, topographical site effects, etc.) as well as the resulting effects (slope instability, liquefaction, etc.). Lastly, seismic microzoning could lead to documents enforceable against third parties, by imposing earthquake-resistant rules which are more appropriate for the local context than seismic zoning rules.

Analysis of the local geological and topographical conditions to calculate site effects

The local seismic hazard is evaluated on a map scale of roughly 1/5,000 or 1/10,000th. At this scale, the geological and topographical conditions likely to lead to the local propagation of seismic vibrations (direct site effects), or to result in other natural dangerous phenomena (resulting site effects) are taken into consideration. As the term “earthquake” indicates, the main effects of earthquakes come from the vibrations associated with waves emitted by the sudden sliding of two lips of the fault. These vibrations may be characterised by their frequency (which may go from 0.01Hz to 50Hz), and their amplitude; the waves which propagate them are characterised by their type (for example, compression or shearing) and their propagation velocity.

The latter, which is relatively stable deep in the earth’s crust, becomes extremely variable when very close to the surface as it is in direct relation with the density of the soil and rocks: therefore, the shear wave velocity varies from 3,000m/s in sound granite, to sometimes less than 500m/s in the same granite but this time severely altered, and from almost 1,000m/s in very compact sediments to less than 50m/s in silt and peat. Hence, the propagation of these waves is very highly affected by these surface heterogeneities, and the same goes for the spatial distribution of the amplitude of the associated seismic vibrations. This spatial variability linked to surface geology is traditionally known as “direct site effects”. Moreover, the seismic rupture (vibration or surface rupture net slip of the soil of the fault plane) may lead to the appearance of other natural dangerous phenomena, such as land movements or soil liquefaction, and even rarer, avalanches or tsunamis. In this case, we talk about “resulting effects” caused by the seismic rupture.

Direct site effects

This involves an amplification of seismic waves directly linked to the topographical or geological configuration of the site; the seismic waves are trapped in the structure. Two types can be distinguished:

- **Topographical site effects**: hilltops, long crests, shelf and cliff edges are the significant amplification focal point of the seismic motion.

- **Site effects linked to the structure and type of soil**: the mechanical characteristics (density, rigidity, compressibility, etc.) and the geometry of the formations (pile-up, valley bottom filling) may accentuate the effects of the seismic motion.

Example of topographical site effects: During the earthquake of 11 June 1909 in the south of France, greater damage was observed on houses situated in the higher areas of the villages. During the seismic vibration, the waves were trapped in the topographical hills, and thus a phenomenon of seismic motion amplification occurred.

Resulting effects
This involves the appearance of a phenomenon whose commencement is triggered by seismic vibrations. Soil liquefaction and land movements are the two main resulting effects.

The phenomenon of liquefaction is a momentary phenomenon. It affects granular areas (sandy or silt-laden horizons) which are saturated with water: seismic agitation may cause the rapid settling of sediments; the water contained in the sediments will thus be expelled. The brutal disintegration of the material results in the deconstruction of the soil: this is the phenomenon of liquefaction. Buildings constructed on soil subjected to the phenomenon will be particularly unstable.

Schematic representation of the phenomenon of soil liquefaction

In the case of land movements: earthquakes may cause land instability by modifying the conditions of geotechnical equilibrium. More often than not, the seismic vibration acts as the triggering factor for ground whose instability was often latent. The land movements concerned may be: landslides in underground cavities, cliff subsidence, rock fall, landslides, etc.

Schematic representation of land movements triggered by seismic vibrations

In certain cases, the rupture of the fault plane spreads to the ground's surface creating a surface rupture along the fault, from a few centimetres to several metres of net slip. This spreading to the ground surface of the fault plane, having been broken, depends on the initial depth of the seismic focus (location of the fault plane where the rupture began) and the magnitude of the earthquake (dissipated energy).
12 – Assess the seismic vulnerability of existing buildings in Alexandria

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerns the current urban situation (current level of vulnerability of existing buildings).</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 4, 7, 8, 11</td>
<td></td>
</tr>
</tbody>
</table>

**Aim**
Assess the vulnerability of existing buildings (as a priority, strategic and public-access buildings, strategic infrastructure in the event of a crisis, etc.) and in accordance with this, set up action priorities to reduce the seismic risk.

**Targets / recipients:** in priority strategic buildings and those that accommodate a lot of people, strategic infrastructure for crisis situations.

**Expected benefits:** avoid building collapse and related deaths and casualties.

**Scale:** local.

**Description**
An earthquake is only fatal when it causes buildings and structures to collapse, except in certain very particular cases (landslides caused by an earthquake, etc.). Hence the need to learn to construct buildings which do not collapse, or at least not quickly (allowing people to leave the building after the first tremor), or which are not subjected to too much damage, and evidently to strengthen the existing buildings.

Present-day urbanisation is formed by buildings and infrastructure characterised by varying degrees of fragility in the case of seismic tremors. And yet, if it is now possible to act on future buildings by proposing suitable construction regulations (see Box 5), it is however also necessary to establish an assessment on the vulnerability of existing buildings, and in accordance with this, set up actions to reduce the risk (see Box 6).

Experience shows that structures, when their design is sound and the normal construction regulations were correctly applied, have considerable chances of withstanding moderate intensity tremors. “Antiseismic” construction firstly assumes compliance with the design, calculation and construction regulations appropriate for non-seismic situations.

Concerning existing buildings, a retro-analysis of them should thus be conducted by calculating what their behaviour would be when faced with an earthquake. In these calculations, it is essential to be able to refer to a reference seismic motion (in that case, it is necessary to refer to the national seismic zoning of Egypt, and if possible to the microzoning of Alexandria – see Sheet 11). Depending on the type of structure, the level of protection sought (or the degree of damage considered to be acceptable during an earthquake) will not necessarily be identical (notion of “performance-based design”).

In accordance with the behaviour diagnosis, it will therefore be possible to propose either strengthening works, or the destruction of the building and the use of another building which has been deemed less vulnerable.

To conduct this retro-analysis, priorities need to be established with the local authorities (choice of strategic buildings, for example) regarding not only the calculation of the buildings’ behaviour when faced with an earthquake, but also the decision making concerning the strengthening/demolition/new use of the building. In addition to the strategic buildings, traditional and old residential buildings, considered to be particularly vulnerable in the case of earthquakes, should also be analysed (perhaps by establishing detailed typologies).
The methodological approach of the seismic vulnerability assessment and the main strengthening options are shown in Box 5.

With respect to conducting retro-analysis and establishing priorities with local authorities, it may also be useful to include a cost-benefit analysis of the expected strengthening/demolition costs of the priority buildings as opposed to expected costs that might be incurred if a reference earthquake is to hit.

**Constraints/difficulties**

Propose analysis priorities, have a team (structural engineers, architects, etc.) which is capable of conducting this type of assessment, set acceptable degrees of damage in accordance with the type of building (usual or strategic)

**Uncertainties**

- Building types and categories to be included in the analysis
- Potential cooperation of local authorities

**Concerned authorities and sectors**

- Authorities in charge: Governorate (coordination), General Organization for Physical Planning, Physical Planning center for Alexandria Region (operator).
- Sectors: infrastructure, building, institutional

**Monitoring and evaluation**

Number of vulnerability studies achieved, number of strengthened buildings.

**Cost**

For a strategic building with a relatively simple architecture: 160 000 -240 000 EGP for a diagnosis with digital simulation of the structure behavior.

**Scheduling**

Short term (< 5 years)

**Joint mapping**

Subsiding areas located by interferometry.
Box 5: Paraseismic regulations

Seismic risk is linked to seismic hazard and vulnerability in construction, which is why an overall paraseismic design approach in construction should be set up. It should rely on the following three points:

- Compliance with paraseismic regulations.
- Paraseismic architectural design.
- Careful implementation of construction.

Paraseismic (earthquake-resistant) rules are a set of construction rules to be applied to buildings so that they can resist an earthquake in the best possible way. The philosophy of rules involves protecting human lives: first and foremost, the objective is to prevent the risk of floors and walls collapsing. The rules allow for possible structural damage in elements such as beams, but absolutely not in posts at the risk of subsidence.

In order to make the technical construction rules consistent within the European Union, the European Commission launched a vast project of structural eurocodes, amongst which Eurocode 8 relating to the calculation of structures in terms of their resistance to earthquakes. Eurocode 8 applies to the measuring and constructing of buildings and civil engineering structures in seismic areas. It sets the requirements in terms of performance and conformity criteria. Its objectives in the case of an earthquake are the following:

- protect human lives,
- limit damage,
- guarantee the operational capacity of the structures which are important for civil protection.

The examples hereinafter are in line with the instructions of Eurocode 8.

Regulatory zoning

Paraseismic regulations to be applied depend on both the area of seismicity where the building considered is situated and the category to which it belongs. The parameter selected to describe the seismic hazard at the national level is the “agr” reference acceleration, “on rock” ground acceleration (the reference taken is rocky ground). The area of seismicity and the building category allow for the determination of the agr acceleration on the rocky ground to be taken into account for the definition of this spectrum.

Buildings’ categories of importance and importance coefficients

The buildings are classified into 4 categories of importance which are contingent on the consequences in terms of human lives in the case of subsidence, the importance of public safety and civil protection immediately after an earthquake, as well as the economic and social consequences in the event of subsidence. The definitions of the categories of importance are indicated in the table below:

<table>
<thead>
<tr>
<th>Categories of importance</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Buildings of minor importance for people’s safety, for example, agricultural buildings, etc.</td>
</tr>
<tr>
<td>II</td>
<td>Common buildings which do not belong in the other categories.</td>
</tr>
<tr>
<td>III</td>
<td>Buildings whose resistance to earthquakes is significant considering the consequences of subsidence, for example: schools, meeting/conference halls, cultural institutions, etc.</td>
</tr>
<tr>
<td>IV</td>
<td>Buildings which are of vital importance in the event of an earthquake for civil protection, for example: hospitals, fire stations, power plants, etc.</td>
</tr>
</tbody>
</table>

A coefficient of importance ($\gamma_1$) is attributed to each category of importance.

N.B.: The European paraseismic regulation is here provided as example, but other similar regulations such as the USA or Japanese regulations could have been presented instead.
Box 6: Evaluation of the buildings’ vulnerability

Reducing the vulnerability of territories to earthquakes means limiting the number of victims, the amount of damage and economic consequences.

Paraseismic (earthquake-resistant) construction allows for the resistance of buildings to be strengthened and the number of victims to be considerably reduced. For existing buildings that were not built in accordance with the earthquake-resistant construction rules, a vulnerability diagnosis needs to be carried out, in particular for public-access buildings and buildings whose operations are important in crisis situations. This diagnosis gives ways to the definition of the possible need for and methods of strengthening.

For complex and high-stake buildings, two levels of diagnoses may be considered:

❖ Qualitative visual pre-diagnosis

This will be carried out by an expert in earthquake-resistant construction design by observing the structure’s geometry; it will enable him/her to select the strategy to follow. If the structure has defects which are too significant, it should either be demolished or strengthened or a protection solution should be applied. If the expert considers that works could improve its dynamic behaviour, a quantitative diagnosis should be conducted.

❖ Full quantitative diagnosis

In the event of the pre-diagnosis leading to the possibility of correcting the defects without undertaking excessive expenses, an investigation campaign, i.e. reconnaissance surveys to identify the quality of the materials and the geometry of the elements in place, will be conducted. The value of the diagnosis is thus directly linked to the quality and the position of the investigations, which are often difficult, if not impossible, to access. The calculation hypotheses will sometimes be pessimistic by default to go in the direction of safety, although this has a penalising effect on the operation amount. Strengthening an existing structure assumes that its dynamic behaviour is known through computer simulations and in situ measurements; before the strengthening to estimate its response, and after the strengthening to validate the efficiency of the works to be considered. This diagnosis phase is very delicate to manage. It involves close collaboration between the soil mechanics engineers and the structural mechanics engineers.

❖ Strengthening solutions

Regardless of the type of building, two strategies may allow for the reduction of the effects of an earthquake to be dealt with:

1. Either locally operates on the structure, through the creation of confinement spaces regarding major risks. In this case, this involves constructing earthquake-resistant safety zones within the buildings in order to resolve the issue of protecting the occupants without having to strengthen the structure as such.

2. Or operates on the structure in an overall way. This generally means major works which should be technically and economically validated.

The currently available strengthening techniques are categorised by objective and technology:

- Soil treatment (injection, micropiles, vibroflotation, chipping, etc.)
- Strengthening by adding elements (chaining, shear wall, abutment, etc.)
- Increase of sections and confinement (shotcrete, bonded composite, steel lining and corseting, etc.)
- Realisation of anchoring (floor-chaining, framework-chaining, foundation-framed structure, etc.)
4. Control of Coastal Erosion and Marine Submersion

13 – Set up a tsunami downward warning system

<table>
<thead>
<tr>
<th>Time period</th>
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<tbody>
<tr>
<td>Concerns both current urban situation (enables improving anticipation and management of tsunami risks) and future urban development (2030 horizon).</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

Other related sheets: 2, 3, 15, 18

**Aim**

Improve the prevention of tsunami risks by means of setting up an early warning system with the aim of taking the necessary local measures as soon as the signal is given.

**Targets / recipients:** authorities in charge of the prevention and management of tsunami risks.

**Expected benefits:** population early warning could reduce most of the casualties in case of tsunami.

**Scale:** national.

**Description**

A tsunami warning system is a system used to detect tsunamis and to emit warnings to avoid the loss of lives and goods. Through the impetus given by the UNESCO Intergovernmental Commission, an early warning system for tsunamis and mitigation should be installed in the Mediterranean. This system is planned to start between now and 2 to 3 year’s time. It will be formed by 2 regional platforms: one in the eastern part of the basin (managed by Greece and Turkey), and a second one in the western part (managed by France). Both of these additional regional warning centres correspond to the upward part of the early tsunami warning system, in other words, in the seconds or minutes following a tsunamigenic event (earthquake, major landslide, underwater volcanic eruption, etc.), they should inform the various countries on the possibility of a tsunami occurring on the coastline. Each country is then responsible in its territory for managing this warning; this corresponds to the downward part of the warning system.

The northern Egyptian coast is not protected from a tsunami, however, the time between the creation of the tsunami and its arrival on the coastline may be sufficient (several tens of minutes) for the local authorities to take the necessary measures before its impact on the coast, in particular sounding alarms early enough for the most exposed coastal areas to be evacuated.

Within this framework, it is desirable that the Egyptian authorities already be able to organise the setting up of a downward warning system: Where should the information on the detection of a possible tsunami be sent? Should filters be introduced (in accordance with the intensity, location, others?) for the local emission of the alarm? Which authorities should be warned?

Moreover, within the framework of this downward warning system, and failing to have a tool capable of simulating the phenomenon (propagation onto the coast, possible damages, etc.) as soon as the upward information is received, the anticipated realisation of a catalogue of flood and evacuation maps for the ports and the most exposed coastal areas (risk and high stakes) could constitute a useful decision-aid tool as part of managing the rescue teams and urban development. In this respect, the local zoning described in Sheet 15 is complementary. This catalogue of flood and evacuation maps should also be made available to the public in...
the most exposed coastal areas in order to engage the public in hastening the execution of local measures. Furthermore, for the areas which are most exposed, in theory, the need to install sirens and indication signs to warn and inform the population in the case of the imminence of an event should be evaluated.

It should be noted that for an improved quality of the information (position, magnitude, initial apparition time, etc.) on the event detected, the government of Egypt must participate in the good functioning of the upward warning system and this, in particular, by making data relating to earthquakes and tide gauges available, and possibly installing and managing additional instruments, such as tide gauges and tsunami-meters, for example. The installation of these new instruments is currently being discussed by experts convened by UNESCO. Representatives of the government of Egypt are an integral part of this working group.

### Constraints/difficulties
May require some changes in the structure, organisation and operation of the institutional context.

### Uncertainties
Efficiency of the warning system

<table>
<thead>
<tr>
<th>Concerned authorities and sectors</th>
<th>Monitoring and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Authorities in charge: Information and Decision support Centre, National Committee for Crises Management and Disaster Risk Reduction, Civil Protection Administration (preparation and coordination); Governorate (local coordination), districts and municipalities (recipients).</td>
<td></td>
</tr>
<tr>
<td>• Sectors: study, institutional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completion of the warning system, and efficiency in real situation (transmission speed of the information, % of the exposed population informed)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Scheduling</th>
<th>Joint mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>No significant cost (organisational measure)</td>
<td>Medium term (&gt; 5 years)</td>
<td>Medium and high submersion risks</td>
</tr>
</tbody>
</table>

### 14 – Improve knowledge on tsunamigenic sources

#### Time period
Concerns both current urban situation (enables to improve the anticipation and management of tsunami risks) and future urban development (2030 horizon).
Other related sheets: 15

#### Sphere of intervention
There are seven possibilities in accordance with the possible overlaps (see position of the star)

#### Aim
Better evaluate the national risk by improving knowledge on the tsunamigenic sources (location, seismic nature, gravitational, size, probability of occurrence, etc.).

#### Targets / recipients
Authorities in charge of the prevention and management of tsunami risks.

#### Expected benefits
reduce most of the casualties and damages in case of tsunami.

#### Scale
national.
Description

Improving knowledge on the geological origin of tsunamis enables to better define the risk. Seismic sources which are far away (Aegean trough, Levant coast) are those behind the historical tsunamis which are now references (in particular those from the years 365 and 1303).

However, several traces of paleo-tsunamis have been described on the Egyptian coasts (northern Egypt and the Red Sea). Research must be continued: date and evaluate the scale (extension, intensity, etc.) of these paleo-events. Moreover, the meticulous analysis of the historical archives must continue. This is tedious and long-drawn out work, but necessary to establish a catalogue of historical events which is as comprehensive as possible and therefore, to an improved evaluation of the risk (probability and intensity of the phenomenon). The latter work may be conducted in parallel and complement the research of the history of other major natural events.

Besides the analysis of past events, the risk evaluation also concerns the characterisation of geological sources likely to generate tsunamis. The phenomena simulation results greatly depend on the characteristics of the tsunamigenic sources introduced into the model. Concerning the seismic sources, this involves the position of the focus, the focal magnitude, the inclination and the direction of the fault map, the size of the rupture in the ground surface and the type of motion. In addition to these characteristics on the seismic rupture, it is also necessary to be able to indicate the return period of these very strong earthquakes capable of creating a rupture in the ground surface and then a tsunami. At present, the seismotectonic models remain relatively simple regarding both the location of the seismogenesis faults at sea and their activity rate. The research teams, composed of both geologists and seismologists, must continue to acquire information and interpret it to improve knowledge on active faults located on the Aegean trough, along the Levant coast, or closer to the Egyptian coastline with regards to the Rosetta fault system.

Among the tsunamigenic sources, there are also gravitational sources. This generally involves a close source and the tsunami propagation distance will be less significant than for that of earthquakes. Regarding the northern Egyptian coast, the continental shelf and slope must be analysed in order to locate the underwater areas which could be subjected to gravitational motions whose size and mechanism could be sufficient to generate tsunamis. This work can be accomplished on the basis of bathymetric data using geophysical profiles and a geomorphologic interpretation of the different sedimentary substances.

The mapping of the tsunami risk with regard to the Egyptian coasts (and particularly the Alexandria coast) could be established on the basis of an improved knowledge of seismic and gravitational tsunamigenic sources (size, location, recurrence, etc.) by means of the simulation of various phenomenological scenarios and the interpretation of these results (see Sheet 15).

Constraints/difficulties

- Long lasting work (several years), dependent on the results of the research teams on the Aegean trough
- Bathymetric and geomorphologic surveys
- Requires a continuous technological watch

Uncertainties

Reduced by improving the knowledge on tsunamigenic sources

Concerned authorities and sectors

- Authorities in charge: Information and Decision support Centre (coordination); Governorate (recipient), National Research Institute of Astronomy and Geophysics (operator).
- Sectors: study

Monitoring and evaluation

Completion, performance and implementation of the study.

Cost

Depend on the scope and level of detail of the survey

Scheduling

Very short term (< 2 years)

Joint mapping

No
### 15 – Local zoning of the tsunami risk and damage scenarios in Alexandria

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerns both current urban situation (enables to improve the anticipation and management of tsunami risks) and future urban development (2030 horizon).</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 2, 4, 13, 14, 18</td>
<td></td>
</tr>
</tbody>
</table>

#### Aim
In the sectors which are very exposed to tsunamis, specify the hazard, vulnerability and risk.

**Targets / recipients:** authorities in charge of the prevention and management of tsunami risks.

**Expected benefits:** reduce most of the casualties and damages in case of tsunami.

**Scale:** regional.

#### Description
Analysing the tsunami risk within the framework of this study meant that it was possible to show that the risk of a tsunami exists. Several destructive historical tsunamis are known for having destroyed the city of Alexandria.

Besides the need to refine knowledge on the possible tsunamigenic sources (near or far) and the probability of occurrence of the corresponding tsunamigenic rupture (see Sheet 14), for an improved cartography of the tsunami risk on the coastal sectors which are, in theory, the most exposed (high susceptibility in terms of tsunamis and/or high stakes), the following is necessary: acquire the detailed bathymetric and topographical data (see recommendations on coastal erosion); take into consideration the coastal infrastructure and facilities in simulation models; and carry out detailed simulations, in particular for the water propagation onto the land (directivity of the flow and ebb, speed, height, duration, etc.).

Tsunamis experienced during the last decade enabled to calculate functions of vulnerability for structures as ships or buildings. Regarding human vulnerability, it is more complex. It depends on the location of people at the time of the tsunami:

- For the population outside of buildings, a single vulnerability curve can be calculated. The two parameters used are the speed and height of flooding.
- In case of people inside buildings: a typology of buildings has to be established, and for each type a curve of vulnerability calculated. For tsunamis of low up to medium intensity, most types of buildings can serve as a shelter.

Moreover, for a given tsunami event, to obtain a better evaluation of possible damages, it is recommended to take into account various periods of occurrence: day / night, summer / off season.

The evaluation of the structures' vulnerability, then the realization of damage scenarios, should thus result in locating the sectors where the risk is highest, and therefore where the prevention actions (downward warning system, protection structure, etc.) should be made a priority (see Sheet 13).

#### Constraints/difficulties
- Acquire accurate altimetric coverage
- Skills in tsunami simulation
**Uncertainties**
Probability of a significant tsunami to occur.

**Concerned authorities and sectors**
- Authorities in charge: Information and Decision support Centre (coordination); Governorate, Egyptian Environmental Affairs Agency – Regional Branch (recipient), National Research Institute of Astronomy and Geophysics (operator).
- Sectors: study, technical measure, urban planning, institutional

**Cost**
For the French Mediterranean coast (zoning, damage scenarios, warning system): 1.5 M€

**Monitoring and evaluation**
Completion, performance and implementation of the study.

**Scheduling**
Short term (< 5 years)

**Joint mapping**
Medium and high submersion risks

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**16 – Improve knowledge on the changes of coastal beaches (excluding the Corniche road)**

**Time period**
This recommendation concerns both present and future (2030) urban situation.

Other related sheets: 17

**Sphere of intervention**
There are seven possibilities in accordance with the possible overlaps (see position of the star)

- Urban planning
- Institutional
- Infrastructure

**Aim**
Define the erosion control intervention strategies to be implemented on the coast:

- from the port of Dikheila in the east to the south-western boundary of study area (boundary marked by the presence of four breakwaters and a groyne), i.e. a distance of approx. 52km of coastline characterised by the following:
  - Dense and continuous urbanisation over an approximate distance of 13km. The presence of a group of 7 x 100m-long breakwaters, spaced out 50m to 700m apart, east of “west Nobaria drain” can be noted.
  - Industrial sites over an approximate distance of 3km and two small open ports to the east of the Al Nasria sector.
  - Further towards the west, seaside residences and facilities which are only situated a few metres from the seafront.
- between the port of Dikheila and the west port: El Dukhaylah beaches (two 500m-long beaches),
- inside the east port (460m-long beach),
- on the Corniche road between the east port and El Mandara (12km long),
- for the El Montaza and El Maamoura district in the east of Alexandria (500m beach then 3.4km long),
- North Abu Qir beach (1km long).
The beaches along the Alexandria coastline are formed by sand and vary greatly in width. These beaches were categorised as being at great risk of erosion in Phase 1 of the study except for those located along the Corniche between the east port and El Mandara (Corniche).

Regarding the Corniche coastline, categorised as being at medium risk, the protection strategy to be implemented is different to the rest of the coast, and is the object of the Sheet 17. Today, the Corniche coastline has already been subjected to development works to limit the erosion of the shore (breakwaters, renourishment beaches, groynes, etc.) and artificial beach creation works, whereas on the rest of the Alexandria coastline, these types of development works are inexistent.

**Targets / recipients:** beaches categorised at great risk of erosion in Phase 1 of the study.

**Expected benefits:** to define the protection strategies to be implemented to fight against erosion, knowledge on the actual changes to these beaches should firstly be improved.

**Scale:** local.

**Description**

The characteristics of the beaches on the Alexandria coastline (length of the strand, altimetry, type and granularity of the sediments, thickness of the available sand, etc.) and their changes in accordance with the hydrodynamic conditions are unknown at present. The increase in the sea level resulting from climate change for the study target year (2030) is low (estimated to be 20cm) and should only have a little impact on the changes to the beaches located west of the port of Dikheila: recession of the water mark by a few metres in accordance with the slope of the beach, except on several particular points of the shore where the facilities and housing are already too close to the seafront. The impact of the increase on the beaches located between the port of Dikheila and the west port, inside the east port and east of El Montaza to Abu Qir, will be much greater given the current small widths of these beaches. Consequently, in the short term and on these sectors, greater knowledge on the morphological changes and hydrodynamic characteristics of the shore will allow for better adapted protection solutions which could turn out to be necessary if the water level increase continues. An exceptional storm, combined with the water level increase, would, in the long term, lead to a significant recession of the water mark and an attack on the higher beach areas. Consequently, introducing monitoring which at least includes the realisation, between the higher beach area boundary and the depths of -10m, of the campaigns described hereinafter, will result, in the long term, in answers adapted to the solutions to be implemented:

- **Topographical-bathymetrical survey of the entire coastline** situated west of the port of Dikheila, once every 10 years, using LIDAR technology which allows large surface areas to be covered in a short space of time (see Box 7), and topographical-bathymetrical profiles of the beach at the end of the summer period and the end of the winter period, every year, at the rate of one profile every 1 to 2km depending on the configuration of the beach.

- **Topographical-bathymetrical surveys of the beaches** from the east port to Abu Qir (for the Corniche coastline, see Sheet 17), at the end of the summer period and the end of the winter period, every year, at the rate of one profile every 100m to 500m depending on the configuration and the length of the beach considered.

- **Samples and analyses of sediments:** three on land and four at sea along the profiles, spaced out every 1 or 2km along the west coast and every 100m to 500m along the east coast, once every ten years, depending on the length of the beach considered.

- **Very High Resolution seismic profile survey** (see Box 8) of the entire coastline situated west of the port of Dikheila, spaced out every 5km, to determine the present thickness of the sand that can be mobilised, then after an exceptional storm.
Moreover, the data concerning the **tide gauges**, recorded in the port of Alexandria, should be regularly processed (once a year) so as to be able to establish in the years to come statistics on changes in the water level: levels connected to the tide, surge levels, return periods, etc. This data will be completed with the acquisition of wave data offshore from Alexandria by the positioning of a directional wave recorder.

In urban areas, the **coastal spaces which have not yet been urbanised also need to be protected**. These spaces could, in the long term, form part of the last free spaces on the shore for seaside activities following the long-term effect of climate change on the increase in water levels.

### Constraints/difficulties

Skills required in hydrography, sedimentology and physical oceanography. The following equipment is also needed: seismic and bathymetric sonar, DGPS, sediment samplers, sieve column, granulometric laser, and wave gauge.

### Uncertainties

Reduced by the knowledge we wish to acquire.

<table>
<thead>
<tr>
<th>Concerned authorities and sectors</th>
<th>Monitoring and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Authorities in charge:</strong> Ministry of Water Resources and Irrigation - National Water Research Centre, Egyptian Public Authority for Surveys (supervision), Coastal Protection Authority (coordination), Coastal Research Institute (operator).&lt;br&gt;<strong>Sectors:</strong> study</td>
<td>Completion, performance and implementation of the study. Evaluation of the acquired data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Monitoring and evaluation</th>
</tr>
</thead>
</table>
| **LIDAR:** 1 000 000 to 1 300 000 EGP / survey  
**Granulometric:** 800 000 EGP / survey  
**Seismic:** 160 000 EGP / survey  
**Wave buoy rent:** installing, maintenance and study: 1 000 000 EGP / year | Completion, performance and implementation of the study. Evaluation of the acquired data. |

<table>
<thead>
<tr>
<th>Scheduling</th>
<th>Joint mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term (&lt;5 years) so as to obtain the necessary elements to be able to establish a protection strategy</td>
<td>Medium and high erosion risks in 2030</td>
</tr>
</tbody>
</table>
Box 7: Principle of the LIDAR system

(Source: OpTIMAL project)

LIDAR is an active remote sensing technique that makes use of emitted light. Part of the light is scattered or absorbed by the environment, the rest being backscattered in the direction of the emission source. The interval between the emission and reception signals is used to ascertain the distance travelled, since the speed of light is known. With accurate knowledge of the altitude of an aircraft carrying the system, it is possible to determine the altitude (or bathymetry) of any point targeted in this way. The LIDAR sensing system comprises:

- a telemetric laser,
- an optical system for measurement of the intensity of the backscattered light,
- electro-optical and electronic components for data acquisition.

Absolute positioning of the laser scanner is provided by a GPS and an inertial navigation system (INS). The GPS provides the XYZ coordinates; the INS records the aircraft altitude. Combining the GPS and INS makes it possible to correct for the faults of both systems, the long-term drift in the INS being corrected by the high stability of the GPS.

**Topographic LIDAR**

The topographic Lidar uses an infrared laser in the 1,047 to 1,540 nm wavelength range. The topographic Lidar pulse is subject to multiple reflections from certain obstacles, a property allowing identification of vegetation or other complex targets.

**Bathymetric LIDAR**

Airborne bathymetric laser systems give accurate measurement of water depth by measuring the travel time of two laser pulses with different wavelengths: one, infrared, is reflected by the sea surface; the other, usually a green beam at 532 nm, passes through the air-water interface and is reflected by the seabed. An optical receiver detects the pulses reflected from the seabed and from the surface. The depth of the water is calculated from the interval between these two events after correction for the system's geometry, distortion induced by propagation, wave height and tidal effects.
Box 8: Principles of seismic reflection/refraction

Seismic surveying is an indirect measurement technique that consists in making surface recordings of the echoes from the propagation of an induced seismic wave in the subsoil. The echoes are generated by unconformities in the subsoil that indicate the presence of a reflector in the recordings. Depending on the mode of propagation of the wave, either reflected or transmitted along an interface, the terms seismic reflection or seismic refraction are used (Ifremer, Geosciences Marine, Vol: 21, pp: 25-29, Nov 1999).

Briefly, seismic studies provide an image of the structure of subsurface layers and, in some cases, give information about their nature.

Very high resolution (VHR) seismic surveying, given the frequencies employed (300−2,000 Hz), gives very good resolution, meaning a clearer image of the size of objects. Conversely, the depth of investigation diminishes rapidly depending on the source used.

Coupled with a system that allows investigation of shallow beds, VHR seismic techniques can provide an estimate of amounts of accumulated and images of the impacts of storms on coastal areas, resulting from the migration of sandy materials. The two examples below illustrate the use of VHR seismic techniques.

The image below, obtained with a SEISTEC (R. Certain, doctoral thesis, December 2002) shows the subsurface structure of the Sète Lido (Hérault region, France). It reveals the ‘store’ of sedimentary material that could be moved by storms.

Example of a perpendicular profile:

(USU : Upper Sand unit ; BRL : Beach Rock Layer).

The transparent USU, with a minimum depth of around 6−7 m, envelopes a distinct darker reflector which could correspond to a layer of sandstone already observed by core sampling. No internal reflector is observed.
17 – *Improve knowledge on the changes of the beaches along the Corniche road*

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation concerns both present and future (2030) urban situation. Other related sheets: 16</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

**Aim**
Define the erosion control intervention strategies to be implemented on the Corniche coastline, i.e. between the east port and El Mandara (12km long).

The Corniche coastline was categorised as being at medium risk in Phase 1, due to major urban issues, though the erosion risk was low. Numerous structures such as submerged or emerging breakwaters, or even groynes, are lined along the coastline but there does not seem to be a protection master plan for the Corniche hydrosedimentary system, as is shown by the disparity of development works on the main beaches (from the west to east):

- **Shatby beach**: 260m long and at least 30m wide, giving way to beaches which are several tens of metres long and 3 to 4m wide along the Corniche and which can be observed to the east and west of this beach.
- **Stanley beach**, combined, on both sides of the Stanley bridge, with artificial beaches in connection with a hotel (Hotel Azur) and a sports club (Engineer club) over an approximate distance of 1.2km.
- **Gleem beach** and **San Stefano beach**: beaches whose boundaries are limited by 300m-long groyne-type structures and T groynes.
- **Sidi beshr beach**: 1.6km long and at least 50m wide, it looks out over the open sea. Similar to Shatby beach, it is still not very different to a “natural” beach.
- **Miami Beach**: 450m long, partially protected by Miami Island.
- **Asafra beach** (1,000m long) and **Mandara beach** (1,150m long), protected by submerged breakwaters positioned respectively 250m and 320m from the strand boundary, on the sea side.

**Targets / recipients**: beaches of the Corniche coastline, i.e. between the east port and El Mandara (12km long).

**Expected benefits**: to define the protection strategies to be implemented to fight against erosion, knowledge on the actual changes to these beaches and their sedimentological environments should firstly be improved.

**Scale**: local.

**Description**
The characteristics of the beaches on the Corniche coastline (length of the strand, altimetry, type and granularity of the sediments, etc.) and their changes in accordance with the hydrodynamic conditions and existing protection structures are unknown at present. The increase in the sea level resulting from climate change for the study target year (2030) is low (estimated to be 20cm) and should only have a little impact on the changes to the beaches: recession of the water mark by a few metres in accordance with the slope of the beach, and reduction in the width of the active beach as the possible changes are blocked by the development works at the top of the beach.
Furthermore, in the short term and on these abovementioned sectors, greater knowledge on the morphological changes and hydrodynamic characteristics of the shore will allow for better adapted protection solutions which could turn out to be necessary if the water level increase continues. An exceptional storm, combined with the water level increase, would, in the long term, lead to a significant recession of the water mark and a direct attack on longitudinal protection structures on the Corniche boulevard. Consequently, introducing monitoring which at least includes the realisation, between the higher beach area boundary and the depths of -10m, of the campaigns described hereinafter, will result, in the long term, in answers adapted to the solutions to be implemented:

- **Topographical-bathymetrical surveys** of the recognised beaches from the east port to Abu Qir, at the end of the summer period and the end of the winter period, every year, at the rate of one profile every 50m to 100m depending on the morphological configuration and the length of the beach considered,
- **Samples and analyses of sediments**: three on land and three at sea along the profiles every 50m to 100m depending on the morphological configuration and the length of the beach considered. The periodicity of these samples, after the realisation of a “zero” state, will vary according to either exceptional events (storms) or requests expressed by the “managers” or “users” of the beaches who have noticed a loss of usable surface area of the beach.

In parallel to the establishment of this reference situation, the creation of a **coastal development master plan** for the Corniche could be launched involving both the maritime sector and the land sector of the coastline. It would rely on three phases:

- General assessment of the coastal changes.
- Development scenario proposals.
- Creation of a development master plan.

Moreover, the data concerning the tide gauges, recorded in the port of Alexandria, should be regularly processed (once a year) so as to be able to establish in the years to come statistics on changes in the water level: levels connected to the tide, surge levels, return periods, etc. This data will be completed with the acquisition of wave data offshore from Alexandria by the positioning of a directional wave recorder (see Box 9).

### Constraints/difficulties
Skills required in hydrography, sedimentology and physical oceanography. The following equipment is also needed: seismic and bathymetric sonar, DGPS, sediment samplers, sieve column, granulometric laser, and wave gauge.

### Uncertainties
Raised by the knowledge we wish to acquire.

### Concerned authorities and sectors
- Authorities in charge: Ministry of Water Resources and Irrigation - National Water Research Centre, Egyptian Public Authority for Surveys (supervision), Coastal Protection Authority (coordination), Coastal Research Institute (operator).
- Sectors: study

### Monitoring and evaluation
Completion, performance and implementation of the study. Evaluation of the acquired data.

### Cost
- Survey: 4 000 000 EGP
- Wave buoy rent: installing, maintenance and study: 1 000 000 EGP / year

### Scheduling
Very short term (< 2 years) so as to obtain the necessary elements to be able to establish a protection strategy

### Joint mapping
Medium erosion risk in 2030
Box 9: Wave measurement systems

Wave measurement (direction, amplitude, and period) can be provided from:

- buoys floating at the free water surface, such as DATAWELL buoys, or
- seabed systems such as AWAC

DATAWELL buoy (source: IXSURVEY)

Bottom-mounted current profiler and directional wave sensor with concrete ballast (source: IXSURVEY)

AWAC current profiler and directional wave sensor (source: NORTEK)

Seabed cage housing a current profiler (source: IXSURVEY)
### 18 – Preventing sea submersion risks of the Alexandria coastline

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>The issue of sea submersion is not currently a concern along the Alexandria coastline except for three particular sectors. In fact, this recommendation mainly concerns future urban development (2030) in Alexandria and the current urban situation in several high-risk sectors.</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 2, 3, 4, 8, 13, 15, 19, 20</td>
<td></td>
</tr>
</tbody>
</table>

#### Aim

Limit damages from submersion to the facilities and housing located behind the beach during a storm combined with a high water level.

The present extreme tide surge leads to the partial or total submersion of the Alexandria beaches but the risk of submersion is medium to low on this coastline, except for three sectors:

- The shore between the west port and the port of Dikheila and the banks of the El Noubareya canal which opens onto this sector of the coast (the canal corresponds to the lowest area and will be severely impacted in the event of a storm).
- The El Montaza beach and the western part of the El Maamoura beach.
- The Abu Qir beach (see also Sheet 19).

For the year 2030, without any sufficiently accurate topographical data, it is not possible to conclude that an increase in the water level of 20cm will have a significant impact, compared to the limit of the highest water levels at present. The submersion situation will be slightly equivalent to the one that prevails today. Except for the three previously listed sectors, it does not seem that sea submersion during storms should affect the bordering urban areas (with the exceptional case being the lowest point from the Corniche to El Mandara, submerged in 2003 but in theory rather due to the run-up of waves on the strand phenomenon) and the facilities behind the beach. Only the beach strands are partially or totally submerged as well as the seaside facilities situated directly on the strands.

#### Targets / recipients

see above.

#### Expected benefits

avoid exposure to submersion risk and make the coastline secure.

#### Scale

regional.
Description

Generally, as it is the beach strands and the seaside facilities directly installed on the strands that will be partially or totally submerged, the measures commonly implemented to limit the submersion effect do not apply (for example: longitudinal protection structures, recession, etc.).

In the three sectors where the housing residences can be directly impacted, as they are situated on the border of the higher beach area or along the canal, and prior to any realistic proposals for submersion protection solutions, a present situation vulnerability study is to be carried out. Depending on the results of this study, measures may then be proposed, such as the following:

- Setting up a cofferdam to limit the water pressure on the fronts and windows.
- Raising water-sensitive equipment off ground level in the houses (electric sockets, refrigerator, stove, etc.).
- Moving large-scale equipment to upper storeys in public service-type buildings such as hospitals, clinics, etc.

These measures must be accompanied by the setting up of a reliable, self-sufficient and automatic submersion risk warning system (see Box 10). This could include a system of beacons at sea and on the coast measuring the hydrodynamic and meteorological parameters; the data would be processed by means of a digital modelling tool allowing the shore flooding risk to be assessed and enabling the meteorological forecasts and offshore sea states to be obtained. In the event of the alarm being given, the system could also launch a prevention and safety plan for people (see also Sheet 2).

Uncertainties

Setting up a reliable, self-sufficient and automatic warning system

Concerned authorities and sectors

- Authorities in charge: Ministry of Energy and Electricity, Ministry of Water Resources and Irrigation - National Water Research Centre, Egyptian Public Authority for Surveys (supervision), Egyptian Environmental Affairs Agency – Regional Branch, Coastal Protection Authority (coordination), Information and Decision support Centre – Centre for Future Studies, Coastal Research Institute (operator).
- Sectors: study, construction, institutional

<table>
<thead>
<tr>
<th>Cost</th>
<th>Monitoring and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulnerability study: 120 000 EGP</td>
<td>Completion, performance and implementation of the vulnerability study.</td>
</tr>
<tr>
<td>Warning system : 8 000 000 EGP</td>
<td>Efficiency of the warning system (transmission speed, data reliability).</td>
</tr>
<tr>
<td>Cofferdams : approx. 8,000 EGP / linear meter</td>
<td></td>
</tr>
</tbody>
</table>

Scheduling

Short term (< 5 years)

Joint mapping

Medium and high submersion risks
Box 10: Marine submersion – measurement, information, management and early warning

Independent smart buoys can be placed in the sea. These guardians of the coast – able to communicate with one another, to make and transmit real-time measurements (water depth, wind, pressure, seawall failure, etc.), and to use already available data (weather, tides, ocean swell, etc.) – are able to give advanced warning of the risk of flooding (3D mapping) and to output alert bulletins to authorities and people at risk.

Once operational, this independent, onboard system will represent a major step forward for preparedness and for protection of people and property exposed to coastal hazards, ever more present in today's context of rising sea levels. These systems are currently still in the experimental phase.

The equipment can be permanently sited or mobile, deployed in sensitive areas or transportable and installed in different areas during emergency situations.
19 – Preventing sea submersion risks in the Abu Qir Bay

**Time period**
This recommendation concerns both the present situation and future uses of the sector involved (target year 2030)

Other related sheets: 7, 18

**Sphere of intervention**
There are seven possibilities in accordance with the possible overlaps (see position of the star)

**Aim**
Limit damages from submersion to the following areas during a storm combined with a high water level:

- the area for fishing boats and “industrial” facilities on the western littoral fringe of the Abu Qir Bay (between the north port and the southern drainage canal),
- the agricultural area of the former Abu Qir Lagoon, in case of failure of the El Tarh coastal seawall (situated at +2.5m LAT).

The present extreme tide surge (estimated to be +1.60m LAT excluding run-up) leads to the partial or total submersion of the Abu Qir Bay strands, mainly limited by the road infrastructure, which seems to have a very low altimetry until the end of the El Tarh seawall.

For the year 2030, without any accurate topographical data, it is not possible to conclude that an increase in the water level of 20cm will have a significant impact, compared to the limit of the highest water levels at present, excluding exceptional events. The submersion situation will be slightly equivalent to the one that prevails today, the narrowing of the width of the available strand which could be observed, will vary according to the slope of said strand.

Sea submersion during storms (+1.80m LAT excluding run-up) will strongly affect the grounding area for fishing boats and “industrial” facilities situated on the lowest areas. However, by the year 2030, the sea submersion will have no effect on the area protected by the El Tarh seawall considering its crest level.

**Targets / recipients:** see above.

**Expected benefits:** avoid exposure to submersion risk and make the coastline secure.

**Scale:** local.
**Description**

As it is the strands and the facilities directly installed on the strands that will be partially or totally submerged by combined storm surges and SLR, the measures commonly implemented to limit the submersion effect do not apply (for example: longitudinal protection structures, “strategic” retreat, etc.

Considering the lack of knowledge on the different activities practised on the coastal sector between the Abu Qir port and the El Tarh seawall, and prior to any realistic proposals for submersion protection solutions, a present situation vulnerability study is to be carried out (see Sheet 18). Depending on the results of this study, measures may then be proposed.

However, regarding the Abu Qir fishing shelter, the medium and long-term durability of the activity can only rely on a discussion trying to create a real fishing port. Indeed, in the long term, the present boat grounding areas will disappear as a result of the increase in water levels.

As regards the population and activities located behind the El Tarh seawall, they can safely stay as the infrastructure altimetry guarantees that they will not be submerged. However, this guarantee strongly depends on regular maintenance of the structure.

**Uncertainties**

Topography; rise in sea level; current condition of the sea wall

**Concerned authorities and sectors**

- Authorities in charge: Ministry of Water Resources and Irrigation - National Water Research Centre, Egyptian Public Authority for Surveys (supervision), Egyptian Environmental Affairs Agency - Regional Branch, Coastal Protection Authority (coordination), Coastal Research Institute (operator).
- Sectors: study, construction, institutional

**Monitoring and evaluation**

Acquisition of data through topo-bathymetric surveys and seawall inspection.

**Cost**

El Tahr seawall diagnosis : 100,000 EGP

**Scheduling**

Very short term (< 2 years)

**Joint mapping**

Medium and high submersion risks
5. Flood Control

### 20 – Early warning system, emergency plans and public awareness

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation mostly concerns the present situation, assuming that future populations will be less exposed to flood risks if appropriate measures are implemented.</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 1, 2, 3, 18, 24</td>
<td></td>
</tr>
</tbody>
</table>

**Aim**

To anticipate occurrence of damaging rainfall events, to inform authorities and population and to implement preventive actions.

A warning system is intended to forecast winter storms and risk of heavy rainfall events. No warning system is currently applied in Alexandria.

**Targets / recipients**: population and activities situated in flood prone areas.

**Expected benefits**: prevent and anticipate flood risk by real time information.

**Scale**: regional (the whole Greater Alexandria area).

**Description**

- Set up an **early warning system** able to perform the following tasks in real-time (see also Sheet 2):
  - Early meteorological forecast through a modelling system based on predicted precipitations from radar imagery (every 15 min. for each sub-basin of the catchment area), allowing extreme rain events to be anticipated with pertinent accuracy;
  - Early hydrological forecast, based on a rainfall-runoff model, and a hydraulic model developed for urban areas (supplied with rain gauges, water level recorders, with data collected every 10 min.);
  - Early warning of flood risks by a risk analysis model representing flood intensity and providing immediate correlation of the on-going meteorological and hydrological situation to flood scenarios predefined from the previous extreme flood events;
  - Management and adjustment of flood scenarios and alerts allowing crisis plan implementation to be adapted and sped-up.
- Linked with warning system proposed for **sea storms** (see Sheet 18)
- Put in place an **information channel** for local authorities and rescue teams
- Define **staff and means** dedicated to the crisis management on the field: traffic control, mobile pumps ready for use on the black spots, mobile barriers in some streets (see **Box 11**)
- **Inform** population through mass media
- Prepare **evacuation plans** for slum areas

**Constraints / difficulties**

- Keep the staff available for rare events
- Maintain the required equipment in working order
**Uncertainties**
Climate change; response capacity of local authorities

**Concerned authorities and sectors**
- Authorities in charge: IDSC (supervision), Egyptian Environmental Affairs Agency – Regional Branch, Governorate (coordination), Holding Company for Water and Wastewater, Egyptian Meteorological Authority (operators).
- Sectors: institutional, operational

**Monitoring and evaluation**
Efficiency of the warning system when implemented (simulations or real events).

**Cost**
- Setting up of an early warning system: 16 Million EGP
- Information and awareness campaign: 2 Million EGP
- Preparation of rescue plans: 2 Million EGP

**Scheduling**
- Very short term (< 2 years)

**Joint mapping**
- No
Box 11: Emergency response and information plan for population

Implementation of an emergency response plan makes it possible to organise rescue operations before flooding or other forms of hazard strike. Plans usually comprise the following elements:

- Presentation and analysis of the risk in a given area: risk maps
- Organisation and modalities of activation of crisis cell
- Crisis management (in the form of information sheets):
  - Organisational sheets
  - Action/response sheets: intervention, early warning, evacuation, public areas and public access buildings (PAB), reception of victims, identification of affected areas, protection against theft and vandalism, communications, etc.
  - Supporting sheets: crisis directory; services directory; directory of public places and public access buildings; places of shelter; population, including population at risk; plant for works, transport and communication; furniture; human resources; supply; and damage areas; etc.
- Post-crisis management – return to normal conditions
- Further development and updating of emergency plan.

Provision of preventive information to the public and raising public awareness of the flood risk are communication actions associated with the emergency plan. They may be as follows:

- Campaigns to provide information to the general public: distribution of information brochures, use of the media, posters, exhibitions;
- Awareness raising and training in schools and sensitive organisations;
- Display of safety instructions in public buildings (health and educational establishment, administrative offices, etc.).

Example of public information in the USA: “Emergency Preparedness and You”

1. **Get a Kit:** Gather emergency supplies.
   By taking time now to prepare emergency water supplies, food supplies and disaster supplies kit, you can provide for your entire family.

2. **Make a Plan:** Develop a Family Disaster Plan.
   Families can cope with disaster by preparing in advance and working together as a team.

3. **Be Informed:**
   - Learn How to Shelter in Place.
     Centers for Disease Control and Prevention (CDC) and the American Red Cross have teamed up to answer common questions and provide step by step guidance you can take.
   - Understand Quarantine and Isolation
     When quarantine and isolation may be called for, what they are, and how they work.
   - Maintain a Healthy State of Mind.
     Tools for coping with disaster for adults, parents, children, students, and seniors.

Source: CDC Emergency Risk Communication Branch (ERCB), Division of Emergency Operations (DEO), Office of Public Health Preparedness and Response (OPHP).
### 21 – Control runoff discharges in future urbanized areas and in urban renewal programs

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation concerns future urban developments (urban projects until the 2030 horizon). Other related sheets: 6, 22, 23, 24, 25</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

**Aim**

To control runoff discharges in new urbanized areas or in urban renewal programs, in order not to increase runoff discharges downstream. This can be achieved by incorporating in urban development designs storm water drainage constraints and specific devices allowing reducing runoff discharges, taking due account of foreseeable effects of climate change. This will enable not degrading the flood protection conditions downstream.

**Targets / recipients:** Concerns more specifically the following urban development projects: Amreya project (south-west of Alexandria), industrial zone at south Dekhila port, Monquar Al-Hodhod (south of the city).

**Expected benefits:** avoid flood risks in new urban areas and reduce flood risks in already existing downstream urban areas by the same time.

**Scale:** regional (the whole Greater Alexandria area).

**Description**

- **Infiltration** (see Box 12):
  - Infiltration swales, porous pavement
  - according to groundwater level, and soil characteristics
  - pilot sites to be studied in order to know the efficiency of infiltration, and pollution reduction level
  - zoning of groundwater level in order to define appropriate sectors for infiltration techniques

- Include **management of runoff water** in urban master plans (see Sheet 6)
- Improve the efficiency of **rainwater drainage systems** in road construction
- **Regulation** for managing **runoff water**
- **Regulation** for creating **impervious areas** (ratio of green spaces to be created)

**Constraints / difficulties**

- lack of space for runoff water storage
- private interests
- constructing constraints for storage on the building roofs (tightness efficiency to be assured)
- maintenance and cleaning necessary for storage areas and infiltration
- shallow groundwater (bad infiltration conditions)
### Uncertainties

Infiltration possibilities: pilot sites to be studied in order to evaluate the infiltration capacities in different types of areas.

### Concerned authorities and sectors
- Authorities in charge: Ministry of Housing, Utilities and Urban Development, GOPP (supervision), Egyptian Environmental Affairs Agency – Regional Branch, Governorate (coordination), Holding Company for Water and Wastewater, Alexandria Physical Planning Center (operators).
- Sectors: technical measures, urban planning, regulation.

### Monitoring and evaluation
Changes in regulation, changes in green spaces management, number and surface area of urban projects with integrated runoff water storage and infiltration devices.

### Cost
- Institutional and regulation studies: 600,000 EGP < Ct < 2,000,000 EGP / municipality
- Storm water drainage works: 5 Million EGP < Ct < 10 M EGP / municipality

### Scheduling
- Short term (< 5 years)

### Joint mapping
- No
Box 12: Integrated stormwater management

Integrating stormwater management into urban development projects is a challenge for cities. The so-called ‘alternative’ techniques for stormwater management, unlike the conventional solution of mains collection, temporarily detain runoff and, in some cases, allow infiltration of water, thereby limiting the consequences of peak flows downstream. Combined with other urban functions such as roads and pathways, gardens and leisure and landscaped areas these techniques enhance development.

<table>
<thead>
<tr>
<th>Public areas as an integral part of urban development</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Park able to store stormwater from a housing area" /></td>
</tr>
<tr>
<td><img src="image2" alt="Urban square engineered for temporary storage of runoff rainwater" /></td>
</tr>
<tr>
<td><img src="image3" alt="Floodable area in residential quarter" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planted beds for runoff water storage, detention or possibly infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="A bed between two roads" /></td>
</tr>
<tr>
<td><img src="image5" alt="Flat roof that could be engineered for water storage" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Terraces (planted or bare)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image6" alt="Terraces (planted or bare)" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sidewalk reservoir (porous or non-porous surface) and drainage ditches</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image7" alt="Sidewalk reservoir (porous or non-porous surface) and drainage ditches" /></td>
</tr>
</tbody>
</table>

Sources: L’assainissement pluvial intégré dans l’aménagement – Certu; Water sensitive urban design – Engineering procedures – Stormwater – Australia.
### 22 – Enhancement of the current protection level against floods and Master Plan update

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation concerns both current urban areas and future urban developments (2030 horizon).</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 21, 23, 24, 25, 26</td>
<td></td>
</tr>
</tbody>
</table>

#### Aim
- To get a better knowledge of the network
- To improve the protection level of the sewage network, according to runoff drainage
- To take into account climate change assumptions for estimating runoff discharges
- To improve the utilization of the flood water

The conditions of flooding may be worsened because of the combined effect of climate change and increased urbanisation (soil waterproofing). Overflows of the present sewerage system may become more frequent.

#### Targets / recipients: population and activities located in flood prone areas.

#### Expected benefits: keep the protection objectives of the Sewerage Master Plan, taking possible effects of CC into account.

#### Scale: regional (the whole Greater Alexandria area).

#### Description

- **Better knowledge and understanding of the network functioning**, through the network modelling in order to identify the flooded areas (black spots), for different rainfall return periods:
  - analysis of short duration rainfall intensities
  - verification of topographical data and geometry of the network, characteristics of pumping stations, characteristics of streets, …
  - evaluation of waste water discharges at each point of the network according to the population and type of consumption
  - evaluation of sub-catchments (surface, slope, length) and impervious coefficient, in order to estimate runoff discharges
  - calibration (depending on available observations)
  - simulations for different design rainfall, including flows within the network and surface flows (in the streets when network is insufficient)

- **Incorporate assumptions** for:
  - climate change
  - population growth \(\rightarrow\) increase of wastewater discharges (depending on assumptions about consumptions evolution – see Sheet 26 – Water Resources Management)
  - increase of urbanized surface areas (depending on the control of runoff discharges from new urbanized areas: see Sheet 23 hereafter)
### Constraints / difficulties

Modelling: Cost of modelling study, training program, software availability

### Uncertainties

Different scenarios to be considered on population, water consumption, managing runoff discharges in new urbanized areas, climate change, ...

### Concerned authorities and sectors

- Authorities in charge: Egyptian Environmental Affairs Agency – Regional Branch, Governorate (coordination), Holding Company for Water and Wastewater, (operator), Egyptian Meteorological Authority (short duration rainfall analysis).
- Sectors: infrastructure, technical measures, urban planning

### Monitoring and evaluation

Completion, performance and implementation of the new sewerage master plan: on-going actions, ended actions, reached objectives ...

### Cost

Variable, depending on the modelling level of detail (to be determined by the Holding Company for Water and Wastewater)

### Scheduling

Short term (< 5 years)

### Joint mapping

No

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### 23 – Control and reduction to runoff discharges in existing urban areas

#### Time period

This recommendation mostly concerns the present situation, assuming that new urban development will incorporate appropriate measures (see Sheet 21).

Other related sheets: 7, 8, 21, 22, 24, 25

#### Sphere of intervention

There are seven possibilities in accordance with the possible overlaps (see position of the star)

#### Aim

- To control runoff discharges in existing urban areas, in order to reduce the runoff water entering into the sewage network. The aim is to improve the flood protection level of the sewage network.
- To improve the flood protection level of the sewage network by controlling runoff discharges from urban areas and reduce the loss of runoff water into the sewage network.

#### Targets / recipients

Population and activities located in flood prone areas.

#### Expected benefits

Suppression of currently flooded areas.

#### Scale

Regional (the whole Greater Alexandria area).
### Description
- **Discharge runoff water to the sea** (only if not mixed with waste water), wherever it is possible by gravity (e.g. on the Cornish Road). Water pollution to be watched: regular cleaning of streets, settling tanks and oil traps before final discharge.
- **Infiltration** : see Sheet 21

### Constraints / difficulties
- Lack of space for runoff water storage : high urban density in the already urbanized areas, especially in the old parts of the city
- Cleaning of network results in waste management issues (sludge)
- Watertight roofs : difficult for existing roofs, already problems of roast due to the proximity of the sea

### Uncertainties
Climate change : rainfall assumptions, sea water level

### Concerned authorities and sectors
- Authorities in charge: Egyptian Environmental Affairs Agency – Regional Branch, Governorate (coordination), Holding Company for Water and Wastewater (operator).
- Sectors: infrastructure, technical measures

### Monitoring and evaluation
- Impervious surface area drained to the sea

### Cost
- No extra-cost for new drainage projects but retrofitting of the present network is expensive

### Scheduling
- Medium term (> 5 years)

### Joint mapping
- No

---

### 24 – Manage floods in urban areas

#### Time period
- This recommendation mostly concerns the present situation, assuming that new urban development will incorporate appropriate measures.
- Other related sheets: 4, 7, 8, 20, 21, 22, 23, 25

#### Sphere of intervention
- There are seven possibilities in accordance with the possible overlaps (see position of the star)
  - Urban Planning
  - Infrastructure
  - Institutional
### Aim
To reduce the consequences of floods in Alexandria urban areas. Floods concern mainly streets, with water height probably less than 0.5m. Flooding is due to network insufficiency (depending of the protection level – to be defined in the reviewed master plan).

**Targets / recipients**: population and activities located in flood prone areas.

**Expected benefits**: reduction of the consequences of floods in flood prone areas.

**Scale**: regional (the whole Greater Alexandria area).

### Description
- **Flood mapping** in order to locate the black spots, and identify preferential flow directions (see Sheet 22)
- Specific devices and procedures for making buildings less vulnerable (see Box 13)
- Traffic control devices on the black spots (e.g. traffic mobile barriers)
- **Improve the efficiency of rain gutters** in the lowest points of the streets : detailed review of the street drainage conditions, maintenance and cleaning (Sheet 23)
- **Reduce runoff water discharges** (urban development to be controlled, in coherence with the sewerage master plan) (Sheets 21, 22, 23)
- **Mobile pumps** to accelerate the drainage of lowest points when flooded
- **Information** panels on black spots, public information about possible floods
- **Warning system** and crisis management : Sheet 20
- **Evacuation plans** for slum areas (Sheet 20)
- Reduction of **population densities** in exposed areas
- **Education** and raising awareness (Sheet 20)

### Constraints / difficulties
- Cleaning of network results in waste management issues (sludge)
- maintenance of pumps (fixed or mobile)

### Uncertainties
Climate change

### Concerned authorities and sectors
- Authorities in charge: Egyptian Environmental Affairs Agency – Regional Branch, Governorate (coordination), Holding Company for Water and Wastewater (operator).
- Sectors: infrastructure, technical measures, institutional, operational

### Monitoring and evaluation
- Feedback after floods (changes in flooded surface areas).

### Cost
- Mainly organisational measure

### Scheduling
- Very short term (< 2 years)

### Joint mapping
- Flood prone areas
Box 13: Making houses and businesses less vulnerable

When houses cannot be placed totally beyond the risk of flooding, steps can nonetheless be taken to minimise resulting damage and to facilitate repair.

‘Avoidance’ strategy: technically, this is only possible for new houses. The living areas are placed above water level: creation of a crawl space, building on ‘stilts’, first floor on basement or above-ground garage, etc.

‘Resistance’ strategy: prevent the water from entering the building by sealing off possible access points: doors, windows, distribution networks (non-return valves). This strategy can only be implemented under certain conditions:

- Water level above floor less than 1 m (greater depths create pressure problems for the walls), moderate flow velocity, limited duration of flood (less than 48 hours, beyond which there is a risk of invasion of the building and isolation of occupants who have remained inside),
- Warning received sufficiently in advance to allow installation of protection (sand bags, sluice gates, movable barriers).

‘Resilience’ strategy: allow the water to enter the building but take steps to reduce damage: raise electrical network and household appliances, choose water-resistant materials (tiled floors, sealed wall bases) or materials easy to replace, etc. In cases where water levels may be high, create a safe area.

These strategies will not reduce damage in all cases and especially not in areas exposed to fast flowing water.

Businesses often experience severe damage from flooding either directly (damaged buildings, plant and utility networks, stocks, etc.) or indirectly (temporary loss of activity, operational losses). The economic and social consequences can be great and can extend well beyond the flooded areas. Grouping of businesses in business parks and industrial estates means that a number of companies are often affected.

A vulnerability assessment is the first step towards measures to reduce companies’ vulnerability to flooding.

The aim is for the greatest possible number of companies to develop a ‘Company Safeguard Plan’. The main categories of vulnerability reduction measures are those concerning ongoing adaptation of activities, measures to permanently position material assets at greater height, measures to move material assets and measures to protect the company.

As a preliminary step, an accurate flood risk map should be produced and the vulnerability of the utility networks on which the company depends (for energy, communications, transport) should be accurately determined. An essential point for the success of this approach is that the businesses should be supported by qualified and accredited people who have the necessary and appropriate resources and legitimate status.

25 – Cleaning and maintenance program of the sewage combined network

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation concerns the present situation as well as future urban developments (horizon 2030). Other related sheets: 7, 8, 21, 22, 23, 24</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

**Aim**
Regular cleaning of network and rainfall gutters in order to maintain the capacity of the network to drain runoff water.

**Targets / recipients:** population and activities located in flood prone areas.

**Expected benefits:** reduction of the consequences of floods in flood prone areas.

**Scale:** regional (the whole Greater Alexandria area).

**Description**
- Analysis of the actual situation regarding maintenance issues: equipments, number of workers dedicated to maintenance tasks, aims …
- Propose strengthening of the maintenance plan: specific equipments if needed, more workers …
- Planning of cleaning and maintenance actions
- Maintenance and cleaning concerns:
  - pipes
  - pumping stations
  - rain gutters
  - infiltration features (see Sheet 21)

**Constraints / difficulties**
Cleaning of network results in waste management issues (sludge disposal)

**Uncertainties**
Removed after a thorough review of the present situation and needs.

**Concerned authorities and sectors**
- Authorities in charge: Governorate (waste management), Holding Company for Water and Wastewater (operator).
- Sectors: infrastructure, technical measures, institutional, operational

**Cost**
To be evaluated by the operator.

**Scheduling**
Very short term (< 2 years)

**Joint mapping**
No
## 6. Water Scarcity Management

### 26 – Control and optimization of water consumption

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation mainly concerns the future situation (no shortage risk in the present situation)</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 1, 6, 22, 27</td>
<td></td>
</tr>
</tbody>
</table>

### Aim

To control and optimize water consumption for all uses, and to improve efficiency of water distribution network.

### Targets / recipients

Population and activities in the Greater Alexandria area.

### Expected benefits

More rational and efficient use of water, in order to avoid shortage situations.

### Scale

National (this is at stake at national level).

### Description

**Domestic consumption:**
- Reuse of “grey water” in the habitations
- Price tariffs to be revised (incentives for water consumption reduction), in relation to socio-economic standards and income of the city
- House keeping measures and practices

**Industrial consumption:**
- Optimize industrial processes to reduce water consumption (for example, reuse of wastewater)
- Price tariffs to be revised (incentives for water consumption reduction)
- Monitoring the quality of the dispensed water to the grid

**Agricultural consumption:**
- Low consumption irrigation modes (Green Irrigation Models)
- Select crop types according to water needs / future climate change scenario (wet/dry) national per capita food consumption / agriculture policy projections
- Reuse of agriculture drainage water
- Reuse of treated waste water (see Sheet 27)

**Improve efficiency of the distribution system:**
- Assess the efficiency of the system
- Rehabilitation of distribution system
- Program for reducing the leaks
- Water footprint assessment per capita and industry as well

**Constraints / difficulties**
- Changes in tariff policy likely to be unpopular
- People awareness about water scarcity
- Private sphere for industrial consumption
- Need of regulation and rules for water consumption
- Renovation cost of the water distribution system

**Uncertainties**
Evolution of water resources in the context of CC.

**Concerned authorities and sectors**
- Authorities in charge: Ministry of State for Environmental Affairs, Ministry for Trade and Industry, Ministry of Agriculture and Land Reclamation (administrative supervision), Governorates (local coordination), Potable water company (operator).
- Sectors: infrastructure, urban planning, regulation, institutional, operational

**Monitoring and evaluation**
Changes in water consumption, water recycling.

**Cost**
No extra-cost if assuming that investments for water consumption reductions are paid back by savings in water resource. However, the rehabilitation of the distribution network may be very expensive.

**Scheduling**
Medium or long term (> 10 years)

**Joint mapping**
No
### 27 – Reuse treated wastewater and sludge

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation mainly concerns the future situation (no water shortage risk in the present situation).</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
<tr>
<td>Other related sheets: 26</td>
<td></td>
</tr>
</tbody>
</table>

#### Aim
To increase the reuse of treated wastewater and sludge, in a situation of growing water scarcity and growing.

**Targets / recipients:** industrial and agricultural activities in the Greater Alexandria area.

**Expected benefits:** more rational and efficient use of water, in order to avoid shortage situations.

**Scale:** national (this is at stake at national level).

#### Description
- Secondary treatment for all WWTP
- Reduce the pollution coming from industrial drainage
- Determine the crop types able to be safely irrigated with treated waste water. Treated waste water should be better used for wood production and other non-food productions (sanitary and toxic problems for other crops).
- Treated sludge: quality to be checked; if quality is improved (industrial pollution reduced), wider use as fertilizer would be possible in the agricultural sector.

#### Constraints / difficulties
- Sanitary and toxic problems for some crops, either for treated waste water, and for sludge used as fertilizer
- Private sphere for industrial activities

#### Uncertainties
Toxic, hormone, and heavy metal concentrations in treated waste water and sludge
Natural elements from industrial, municipal and agricultural activities (nitrogen, phosphorous and potassium in addition to other chemicals)

#### Concerned authorities and sectors
- Authorities in charge: Ministry of Water Resources and Irrigation, Ministry of Health and Population (administrative supervision), Governorates (local coordination), Holding Company for Water Wastewater (operator).
- Sectors: technical measure, institutional, operational

#### Monitoring and evaluation
- Volume of reused treated wastewater and sludge

#### Cost
No extra-cost if assuming that investments for water recycling are paid back by savings in water resource (but this assumption relies on possible growth of water price in a context of water scarcity)

#### Scheduling
Medium or long term (> 10 years)

#### Joint mapping
No
1. Methodology

1.1 Introduction

Economic analysis is one of the main tools assisting in decision making. By making it simple, it is possible to consider this attempt as a transcription, in a more familiar language to decision makers, of the ways to contemplate the problem – in this case, between the different urban planning options – as considered by the technical experts. Aside from some rare exceptions, this transcription requires simplifications. Those considerations concern the transformations or projections of the different problematic considered in the sole economic dimension. Once in this economic dimension, things become relatively accessible as it is only a matter of comparing numbers. Economic dimension and its metric are intuitive and this is why the present problem is issued in it. The whole stake lies in this dimension projection processes, in other words in the economic translation of the themes potentially interesting urban planning. It is therefore necessary to remind that the results given lie on a particular methodology and that the numbers take their meaning only if interpreted in this context.

Given a level of effort (time and budget) one might understand that the choice anyone undertaking such type of exercise has to face:

- If one takes in consideration a large number of relevant themes, there is a risk of dilution in terms of effort; the quality of the projection will suffer either because the figures provided will not have sufficient ground or because the reporting will remain solely of qualitative nature.
- Conversely, not taking sufficiently into consideration the different aspects of the problematic (restricted perimeter) means that the projection would only correspond to a partially faithful transcription, maybe not interesting or useful enough for the problematic considered.

Therefore there are two underlying issues while establishing a tool for decision making:

- To find the minimal level of effort required in order to inform satisfactorily the decision process. The more complex the problem is (number of thematic, temporal horizon, state of the art etc.) the more important the level of effort should be.
- Given a level of effort, to find the right balance between a sufficiently faithful and relevant modeling of the issue under scope and the model capability to generate quantified data.

The second point has been the cause for numerous methodological clarifications during the first phase. Others, complementary and more specified to the second phase are reported here. It is the content of the two following sections concerning horizon, discounting or flows profiling.
The question here is indeed that the lack of consideration of the temporal dimension – or horizon – would empty the analysis of its meaning as urban planning comes within the scope of time. Taking into consideration this constraint requires additional work: discounting. This step enables to ensure the fungibility of the calculated monetary value. As the notion of currency evolves with time it is therefore as incorrect to add two values of the same currency at different times as it is to add two variables of different units.

The calculations are made in Section 2 and a synthesis concludes the economic analysis. The previous argument is synthesized in the following diagram. Even if it has a capability of quantifying things, the level of information is still too low for taking some decisions (hatching in yellow). But quantifying no matter what is not the solution. Indeed, if the means are insufficient, this is automatically translated into an excessive simplification of the representation of the problem or modeling (see the shapes of the iso-investment curves). Yet by simplifying too much, results lose their meaning for the decision maker (hatching in red) even if they are quantified. The ideal situation is to have at disposal a model close to reality that also enables a precise quantification. In the next sections and in line with this, it will be shown that in the study of disasters in Alexandria, some part of the work could only be approached qualitatively, or with more primary quantitative considerations. Some others, like anti-seismic measures or cumulated damages of climate change on health, could be quantified with more accuracy.
1.2 Time Horizon

There is no particular criterion that enables to set the horizon to be considered. Several cases can be made on this point, but not all of them are valid here. The main ones are stated bellow and then discussed before eventually laying out the approach (see 1.4):

1. It is necessary to adapt the horizon to the life expectancy of the measures proposed (namely infrastructures)
2. It is required to take an horizon the longer possible in order to be able to take into consideration the issue of sustainability (namely for the future generations)
3. The horizon needs to be limited to a reasonable term as the societal choices can neither be understood nor anticipated on the too long term. It is better to take a purposely limited period of time with trustworthy data.
4. The horizon has to correspond to the maturity of the necessary loans for the project in order to reinforce the credibility of the choices to the creditors and to avoid discrepancies between social and financial appraisal.

The first assertion is the most natural as it constitutes the closest adaptation of the horizon generally considered when one considers the calculation of the Net Present Value (NPV) for an investment project. The major difficulty is that in the present case the adaptation measures are so numerous that there will consequently be a large number of horizons. The choice could be orientated towards the maximum of the different horizons considered or the horizon which measure(s) has the greatest impact on the NPV calculated. Another difficulty is to evaluate the durability of some measures, particularly that not depending on the building of infrastructures and typically the regulatory or institutional ones. Following this assertion the horizon would be between 20 to 50 years.

The second assertion is common for projects which not only are commercial investments but which have an impact on the overall society. It is also a way of assessing the profitability of heavy investments, if the discounting is limited to the same period. With this optic, the horizon can vary from 50 years to an infinite period of time.

The third assertion could be considered as the viewpoint of the “technician” concerned of the validity of the numbers used in the calculation presented to the decision maker. This dilemma goes in the same direction as that presented in the introduction: what to choose between having solid data giving no real description of the system studied or describing meticulously the system with less reliable data? Even if by preferring the quality of the data to the complete landscape of the problem, the multiplicity of horizons remains (each variable has its own horizon, see first assertion). Moreover, the confidence intervals of the different variables are not consistent but rather spread over time. For instance, the climatic results considered are valid for a period of 30 to 50 years while the unit costs of real estate and economy are based for the 20 upcoming years. From today to 2030, hypothesis of growth are based on the evolution of the GDP. The IMF and the World Bank propose some material on which the present hypothesis have been built. Would it make sense to extend this approach to longer horizons (30, 50, 100 years or even more)?

The fourth assertion would be that of the ‘banker’. As a matter of fact it would join the idea of that of the technician, even if the means conducting to this conclusion are different. It is permitted to consider counting the services given by some options of planning even if the
benefits related to this services do not represent an effective remuneration (unlike for common investments). Nevertheless, the effective financing needs to be based on a real capacity of paying back the principal and the interests even in the case of a public or semi-public entity benefiting from softer loans.

It is not on the agenda of the present project to define the financing models of the options considered. One could even consider that the decision between different options can easily be taken based on societal criteria and that the financing constitutes another work. The argumentation undoubtedly has limits, as the definitive choice of an option has to be concomitant to the guarantee of disposing of a credible financing model. Both exercises therefore cannot totally be dissociated. It is important to give in mind that no matter which options and financial model are chosen, it is inevitable that the horizons of short and medium term (let’s say the 20 first years) keep an particular importance.

Those various points of view illustrate the main possible arguments and their respective advantages and drawbacks. It would nonetheless be inappropriate to make a choice only based on the horizon. Indeed, the choice of the horizon is closely linked to that of the discounting rate. The choice needs to be equally based on the couple (horizon, discounting) and not on one followed by the other. For instance if one might want to illustrate this relation, it would be contradictory to highlight the intergenerational link by taking a very long horizon if the discounting is very high. In this case the weight of the financial flows at a certain point in the NPV would almost become insignificant. The choice of the discounting rate is a crucial issue. The consultant will proceed in two steps in order to fix the H horizon: first is considered until what horizon the temporal discounting is possible in a satisfying way (1.4.1); then the constraints on H on the flows profiling (1.4.2) will be examined.

1.3 Discounting

It is a typical question on which there is no general consensus, especially in a situation different from the basic private short or medium term investment. The category of both public and long term investments has always been controversial. The purpose here is neither to propose its regulation nor to expose in detail the different arguments. It is just necessary to remind briefly the nature of the debate and to propose both an adaptation and choices for the given project.

The purpose of the debate is to determine a discounting rate applicable in all times. The higher it is the lighter is the weight given to the future. Therefore, heavy investments with low return on investment cannot be justified if the rates remain high. The most important question is to know what viewpoint to adopt: given the project, it can be as legitimate to discount weakly from a common interest perspective as to discount highly if one is creditor in order to cover high risks.

This issue has already been faced while considering the right horizon to adopt. In this case it is the decision makers’ point of view that is important. They are in a delicate position as their have to reconcile both general interest and financial feasibility. There is then no simple answer for this situation. Some ethic and responsibility wise considerations tend to favor low rates; but by adopting this standpoint the results might appear absurd or unrealistic, which would dwindle their range. In Stern’s evaluation of climate change damages at the world wide scale, his choice of 1.4% as discounting rate was highly criticized. Nevertheless those figures if given a lot of media coverage can by those means contribute to the debate on climate change adaptation. But Stern’s logic isn’t a planning exercise. The present study case is different: the decision
makers having the responsibility of urban planning future orientation in Northern Africa are specifically in a logic which highly tends to ‘realism’.

Before presenting the chosen approach, it is necessary to ultimately clarify some points in order to avoid any further confusion:

- **Discounting rate cannot be confused with the flows profiling** (costs or profits) which value evolves with time. This is the main reason why, in the first phase, the evolutions of the valorization of the systems considered in 2030 has been meticulously described. The mathematical operation consisting in mentally considering constant flows and therefore to calculate a ‘global discounting’ rate may be source of confusion.

- **Inflation will not be part of the calculation** both for the discounting rate and the flows profiling. The only constraint is coherence as both flows and discounting rates need to be expressed in nominal value or real terms. Beware that all figures presented in the report are expressed in real terms.

- **The discounting rate doesn’t consider any risk evaluation / premium** even if that approach might be necessary in further steps. Models such as financial markets equilibrium model, or arbitration model, which purpose is to precisely determine a rate evaluating the potential risk based on: the rate without the risk evaluation, the global rate of the market, the sensitivity between the investment sector and the market (the famous correlation), or the financing structure (weighted average cost of capital), and also for the present case the sovereign spread. This exercise is necessary but in another optic, one differing from the present study. In reality, this phase would come later once the technical choices made, during the research of private financing for instance (see Vernimmen, 2005 and Ammenc and Al, 2006.)

- Moreover, the part concerning the financing of the project will need to integrate some techniques taking into consideration the specificities of a public or semi-public economic actor in order to evaluate precisely the specificity of its opportunity costs.

1.4 Proposed Approach

1.4.1 Horizon and Discounting

The consultant will here use a discounting rate \( t \) varying from \( x\% \) to \( y\% \) (with \( x>y \)) on the horizon \( H \). The \( N \) first years \( (N<H) \) the rate will be constant and equal to \( x \) and will then progressively decrease towards \( y \) on an infinite horizon.

The actualization rate \( x \) of the \( N \) first years is reached with the economic theory which bottom line is the resolution of an optimization problem (maximization of the collective utility under a budget constraint, what is coherent with a ‘public authorities’ approach), to propose an expression of this rate\(^6\), called the Ramsey-Keynes condition\(^7\):

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\(^6\) Ramsey’s demonstration illustrates that at the equilibrium, the ‘psychological’ rate – right part of the equation, equals the real saving rate \( x \).

\(^7\)
\[ x = \bar{\sigma} + \gamma \mu_n \]

The discounting then seems like the sum of a pure preference for the present \( \bar{\sigma} \) and of a wealth effect: \( \gamma \) is the marginal elasticity of the consumption rate or the intertemporal substitution elasticity and \( \mu_n \) the consumption per capita growth for year \( n \). The determination of the triplet \( (\bar{\sigma}, \gamma, \mu_n) \) enables that of \( x \). As a matter of fact, this value is fixed to 4% in France. It is nevertheless expected that in countries in transition phase, the average value is superior to 4%; indeed the given value is a priori higher as in the consumption growth. The transposition of the elasticity is undoubtedly more delicate. Nevertheless, for ethics reasons, it is sometimes recommended, like in the Lebègue report, to choose \( \gamma = 0 \) in the case of public investment. It would be possible to verify by coming back to technical measures of this parameter, as for instance the average on the considered population of the probability of dying in the year to come. Beyond this approach by a health factor, there is little confidence on this difficult topic, hence \( \gamma \) shall be considered between 0 and 1.5% with a preference for the higher part of the range.

The case of \( \gamma \) is more complex. As shows the Lebègue report, very few data exists in reality in order to determine this parameter in satisfying ways. On a theoretical level, it is possible to establish a relation between \( \gamma \) and the utility function: \( u = c \rightarrow u(c) \): \( \gamma = \frac{-\frac{\partial^2 u}{\partial c^2}}{\frac{\partial u}{\partial c}} \) in which all the derivatives are over \( c \) (consumption). If the utility function is well chosen, the elasticity \( \gamma \) is constant. Indeed when taking \( \frac{\partial^2 u}{\partial c^2} = \frac{c^{1-\delta}}{1-\delta} \), we obtain \( \gamma = \frac{\bar{\sigma}}{\delta} \). Knowing this doesn’t help to determine concretely this parameter and this is the major difficulty of the case. A solution could be to opt for a less sophisticated model and to try a characterization on \( \gamma \) or equivalent based on the saving rate of Egypt for instance... By those means we would be deprived from a well established theoretical framework and from the interesting results that goes with it. The consultant will then keep this approach and will compensate with a sensitivity analysis on the initial rate \( x \). Still according to Lebègue, most of the literature takes \( \gamma \) between 0.5 and 1.5, British choosing \( \gamma = 1 \) for instance. Finally, Lebègue recommends \( \gamma = 2 \), based on the model developed by INSEE, even if the conciliation of different point of views remains difficult on this topic.

Supposing a consensus on the previous point, the issue of transposing \( \gamma \) from an environment to another (France to Egypt) is still to be discussed. Again, with a pretty few confidence on this other point really difficult to tackle both from theoretic or practical (experimental) point of view, \( \gamma \) shall be taken in a range between 0.5 and 2 with a preference for the top of the range (between 1 and 2).

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7 Gollier (Gollier, 2005) gets the same formulae with additional term of second order (the "caution factor", see below). It is important to notice that this modeling explicitly accounts for the intergenerational link (considering the usefulness of an infinite life expectancy individual).

8 With an argument on the fair repartition between generations, values superior to 3 are proposed. It is interesting to see that a same argument can be used for contradictory demonstrations, as often the intergenerational argument intervenes in order to lower the rate.
With the hypothesis that the average consumption equals the production, $\mu_{re}$ is worth the GDP growth per capita in nominal value. This ratio has already been determined in phase 1 on the horizon of 2010 to 2030. Therefore we can take: $\mu_{re} = 4\%$ in this interval.

Therefore we made the $(\delta, \gamma)$ couple evolve in the square $[0 ; 1,5]^3 \times [0,5 ; 2]$ with $\mu_{re}$ constant to 4%. The results on $x$ are the following, the green zone being privileged by the consultant:

<table>
<thead>
<tr>
<th>$\delta$ \ $y$</th>
<th>0.60</th>
<th>0.80</th>
<th>1.00</th>
<th>1.20</th>
<th>1.40</th>
<th>1.60</th>
<th>1.80</th>
<th>2.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,50%</td>
<td>2.40%</td>
<td>3.20%</td>
<td>4.00%</td>
<td>4.80%</td>
<td>5.60%</td>
<td>6.40%</td>
<td>7.20%</td>
<td>8.00%</td>
</tr>
<tr>
<td>1,00%</td>
<td>2.90%</td>
<td>3.70%</td>
<td>4.50%</td>
<td>5.30%</td>
<td>6.10%</td>
<td>6.90%</td>
<td>7.70%</td>
<td>8.50%</td>
</tr>
<tr>
<td>1,50%</td>
<td>3.40%</td>
<td>4.20%</td>
<td>5.00%</td>
<td>5.80%</td>
<td>6.60%</td>
<td>7.40%</td>
<td>8.20%</td>
<td>9.00%</td>
</tr>
</tbody>
</table>

The consultant will finally lead an analysis of the sensitivity on the $x$ factor in the range [4%, 10%], the consultant privileging the upper part of the range. If only one result would be required, the use of $x=7\%$ would be recommended.

Another justification enabling to exclude high rates consists in considering the caution effect highlighted in Gollier’s model (Gollier, 2005). By those means the rate appears reduced from a second order ‘caution factor’ - $\frac{1}{2}\gamma^{\frac{3}{3}}$ in which $\gamma$ represents the GDP’s volatility. This term almost insignificant in developed countries, is a priori less insignificant in a more dynamic economy, even if this trend doesn’t have any major uncertainty (it isn’t shocking to imagine the volatility correlated to the GDP absolute value). Intuitively, this illustrates that on the collective level saving increases with incertitude on the future incomes.

The choice of $N$ different from $H$ results from two factors: on the one hand from the long term uncertainties of the variables in order to define $x$; on the other hand from the issue of having a method that enables to value future generations interests. In France $N$ is taken equal to 30. In the present case, phase 1 enabled to determine some vision of Alexandria until 2030, which is the key horizon. Moreover, the vitality of the Egyptian economy compared to the French makes it in a way less exposed to inertia. Therefore the previsions made on the longer term are more risky. For those two reasons, $N = 20$ will be considered.

Moreover $H$ is fixed to 100 years. It is theoretically possible to consider more important horizons, but it wouldn’t be relevant for this case. The rate on the 20-100 years horizon will be given by the following formula:

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9. Stern has been highly criticized for having a clear preference for the present of 0,1% ; in these conditions indeed, maintaining Ramsey’s equation validity implies strong pseudo assumptions on the profile of the utility curve ; Rather Stern tends to argue of a pure ethical choice. Our approach differs from this one as we wish to show the decision takers all the possible opportunities according to their preferences and not to impose our preferences.

10. Let us remind that in the period of strong growth in France the recommended rate was 8%.

11. Beware of this argument; indeed, Gollier’s modeling is more complex than that of Ramsey and proposes different technical assumptions. Nevertheless both approaches remain comparable.

12. The model is developed on this maximum horizon concerning temporal discounting. Each adaptive measure has its own horizon generally a lot inferior to 100. The flow management (I-4-2) will lead us to reducing $H$. 

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where \( n \geq N \) and \( k \) is a regulation factor for the rate “decreasing speed” or convexity.

In order to set \( k \), it is tempting to impose some intuitive criteria to the function giving the discounting coefficient of the year \( n \) to a rate \( t(n) \):

\[
t(n) = (x - y)e^{k(N-n)} + y
\]

where \( n \geq N \) and \( k \) is a regulation factor for the rate “decreasing speed” or convexity.

The continuity condition on the derivative in \( N \) reality doesn’t give any condition on \( k \), it rather bounds a subset of the cube in which evolve \( x, y \) and \( N \). The decreasing condition enables to give \( k \) a maximum value, but the consultant notices that the solution doesn’t admit any explicit analytical expression.

Digital simulations under spreadsheet enable to come closer to the solution. This requires setting \( N, y \) and \( x \). The consultant chose \( N=20 \) and \( x \) being part of a sensitivity analysis between 4% and 10%. Only the case of the minimum level \( y \) is left to be covered. The determination of \( y \) requires a very long term vision on the Egyptian economy; this exercise is by nature very prospective and concerns the driving factors for change of the 21st century such as the transfers provoked both by demographics and globalization. It is possible to imagine that after the intense catching up phase that is experiencing Egypt, the economy will suffer from the same problematic that Western Europe is facing nowadays: ageing population, economic slowdown…

A minimum level of \( y = 2\% \) shall finally be taken, approximately corresponding to the average growth of countries presenting an economic structure that Egypt will be probably doted of in just a few decades.

The following graphs illustrate \( f \) and \( t \) behavior according to \( k \) in order to set it. In order to draw those curves, temporarily and arbitrarily setting \( x \) (6%) is needed. Nevertheless, the repeated tests showed the low sensitivity of \( x \) towards the choice of \( k \). After various tests in \( x, y \) and \( N \)'s space, \( k=0.02 \) was finally set.
The consultant proposes below a board giving, with identical theoretical flows, the equivalent in constant rate on H (written x*) as well as the mass repartition (weight of the 20 and 50 first years, the total being considered on H=100 years); by this it is wished to come up with a balanced vision, which with constant flow would give the first twenty years over half of the total weight (following x) and a weight of approximately 30% to the thirty next years (2030-2060). The second half of the considered horizon (the period 50-100 years), then weights approximately 20% of the total.

<table>
<thead>
<tr>
<th>x</th>
<th>4.00%</th>
<th>5.00%</th>
<th>6.00%</th>
<th>7.00%</th>
<th>8.00%</th>
<th>9.00%</th>
<th>10.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>x*</td>
<td>3.30%</td>
<td>3.54%</td>
<td>4.62%</td>
<td>5.37%</td>
<td>6.19%</td>
<td>7.07%</td>
<td>8.01%</td>
</tr>
<tr>
<td>mass × 20</td>
<td>45.27%</td>
<td>46.11%</td>
<td>56.02%</td>
<td>56.92%</td>
<td>60.78%</td>
<td>64.55%</td>
<td>68.18%</td>
</tr>
<tr>
<td>mass × 50</td>
<td>76.18%</td>
<td>77.90%</td>
<td>79.65%</td>
<td>81.41%</td>
<td>83.14%</td>
<td>84.82%</td>
<td>86.44%</td>
</tr>
</tbody>
</table>

Let us note that the real weight distribution could eventually end up more balanced, as the flows have been increased by making a whole prospective exercise of the future values (see phase 1 and the following 1.4.2). Therefore, and despite a range of rates that could seem high, the non immediate benefits for the future are well taken in the present approach and so in a realistic way.

The consultant decided to put some particular efforts in the notion of discounting. Indeed, it seems that the sensitivity of this factor deserves both a deep and sensitive reflection. In the absence of sufficient content, sensitivity will not be examined on the flows, which is justified by the impact on the calculations (discounting will impact all flows while the converse is not true). Of course, it is always preferable to cumulate both. It order to be correctly made, this would require a way too sophisticated level of effort (typically using Monte Carlo methods). The uncertainty on the chosen indicator (NPV) is globally superior to that of the variables; nevertheless discounting reduces this phenomenon (which is good as uncertainty increases with time) but in another way, the summing phenomenon induces possible compensations which avoid uncertainties to grow too abruptly.

1.4.2 Cash Flows

The present flows consist in the difference between costs and profits for a given adaptation measure, or a set of given measures, following the calculated indicator. It must be reminded that the “cost” is defined as the effective cost of the proposed measure and the profit as the part of damages avoided compared to the reference scenario or BaU (Business as Usual, see phase 1). For each considered option, four questions relative to flows can be identified:

14 An « experimental » characterization is proposed in (Grelot et al, 2008) with triangular distributions and a Monte Carlo program. If we instead pick Gaussian distributions, which is not less intuitive than triangles, the result is proved directly analytically without any painful calculations. By stability of Gaussian distribution to convolution, the NPV standard deviation is, where $\sigma_i$ is the standard deviation of Xi gaussian (Maisonuneuve, 2001). If we accept the – reasonable - assumption of the variables independency, we indeed end up with a controlled increase of the NPV uncertainty relatively to the uncertainty of its components. The most challenging assumption might actually be that of Xi gaussian, knowing that costs and benefits are definitely not independent.
1. What is the quantitative evolution of those physical flows (‘production’) over time?

2. How to value in cash a flow given in year i taking into consideration its relative value in the world as it will be that year i?

3. Once the flow quantified and valued at the year i, how can this value be converted in present value?

4. Is this current value the same everywhere?

All of these questions constitute an essential component of the ‘translation’ in current terms of a situation evolving through time; it is respectively question of quantity components, relative value, temporal value and spatial value of flows. The treatment of those components enables to converts those facial future flows in order to count them in net present value.

The approach developed in 1.4.1 confines the discounting rate to the treatment of the **temporal component of flows**. The third question is then settled.

The **spatial component** (question #4) takes into consideration the geographical position of the flow emission. It is then question of currency conversion. In the optic of project financing, this component conveys a risk (of exchange) it is important to value. The present approach is different and the consultant will only work in EGP, therefore without being concerned by this issue.

Let us now imagine a simple project, like the production and sale of a good G. Knowing on the one hand which quantity of G will be sold each year and on the other hand the evolution of the value of one unit of G takes back to questions #1 and #2. Those two pertain to the flow issue. It is not uncommon though to encounter models in which flow profiling only account for volume variations (quantities). The unit selling price, when subject to a constant annual indexing, is transferred to the denominator’s position and it therefore integrated to the discounting perimeter. The discounting is then reduced from the growth rate value of one G unity. This common practice can, in some complex cases, induce mistakes. The proposed approach, based on existing best practices, has the capacity to deal with any case with clarity.

**Question #1 – quantitative component** – is about the variation of flows’ volume over time. It is in the present case rather simple to consider: for instance if the rainfalls increase with time, other things being equal, disaster damages will also increase. The application of the concept doesn’t represent any problem methodological wise, nevertheless there is a difficulty concerning the study: the level of effort and the ToR do not coincide with a methodological evaluation of the flows over different horizons. To go back to the previous example, it would be necessary and more rigorous to make an effort of projection in regular intervals all along the considered horizon, for example every 10, 20 or 30 years. The phase 1 has already identified and discussed this issue thoroughly. This study is actually making this exercise of projection only for the 2030 horizon.

This issue is more about profits than costs. Indeed, the **corrective actions do not vary much in quantity**. It can be argued that in the case of infrastructures, the maintenance can be related to hazards frequency and intensity, both variables over time. Uncertainties are too high in this sector in order to assess them in a credible way. Costs volumes will be taken in the top of their respective range (conservative principle).
It is now about determining in a simple way, how the variations of the volume of profits can be represented. In a given time, those quantitative elements depend on the hazard as it is question of the avoided damages. If abstraction is made of climate change, hazards can be considered as constant (it is expressed as average annual cost – AAC). Yet the climatic modeling results only give valid indications for the 2030-2050 period. As for each hazard the consultant managed to evaluate the part of the AAC chargeable to the CC, it is proposed to handle the topic of the evolution of hazards as follows – hence defining the $\Delta_{CC}$ coefficient:

- Between tomorrow and 2030, take a positive annual growth the ratio of the flow between 2010 and 2030 is $(1-u)$ where $u$ represents the imputable percentage to the CC calculated in phase 1 for the considered hazard;
- Between 2030 and 2050, keep the flow identical; it is clear that this is to ease calculations rather than to account for the physics of climate change which probably presents more continuity. There is no issue here since we are mostly interested in indicators that aggregate the information about flows (such as NPV or B/C) rather than to flows as such; yet we hardly could be confident about a single flow value even if we wished given the uncertainties characterizing both the topic and the approach.
- Between 2050 and 2110; $\Delta_{CC} = e^{\frac{3}{10} \ln (1-u)} - 1$ could be convenient (see annex 1). Annex 1, which object is to discuss more globally of $\Delta_{CC}$ and $\Delta_{F}$ concludes on the pertinence to work on a 40 years horizon – until 2050, as an application of the conservative principle (among others).

It is then found that the hazards induce a variation of the volume on the profits as much as they are related to climate change.

The variations of volume have to be considered following the different components of the profits: hazards and vulnerability. On the theme of hazard, the limiting factor is the complexity of climatic sciences and its link to disasters. This complexity is real\(^\text{15}\). Unfortunately, in the case of vulnerability, it isn’t less significant, if not more important. Indeed, the unknown variable in this case lies in the societies’ attitudes: demographics, planning choices, etc… The anticipation of such evolutions on far horizons is obviously prospective, nevertheless the risk of not undertaking this exercise, according to the Consultant, could constitute a mistake potentially greater than the uncertainty of such approach.

The vulnerability concerns both direct and indirect cost, so, in order to get it simplified, it is related to the real estate on the one hand, and to the labor market on the other hand (see phase 1). Even if, from a methodological point of view, it is interesting to decompose the evolution of vulnerability according to its variation in volume or in unit value, the indicators of easiest access mix those two aspects (typically the growth of a sector or of the economy globally). Therefore, in the present perspective, it doesn’t seem opportune to disintegrate the two dimensions – quantitative and qualitative – from vulnerability: they are approached in one bloc; before that, let us clarify what does the variation of the flows values represents (following paragraphs).

\(^{15}\) Intrinsically but also because the CC intensity depends on human behavior on a global scale.
The question of the relative value of the flows (question #2) seems subtle. What meaning give for instance to the loss of opportunity of a good G in i years? If the world in i years is similar to that of today, the loss is identical (the consultant is not talking here of the temporal dimension, that being the subject of a specific discounting). In contrast, whether the good G has grown scarce or in the opposite has become of common use, its value will a priori increase or decrease. Particularly when the good or the service is not substitutable (like it is often the case for natural goods and services), its relative value increases. Likewise, and still out of the temporal dimension, if in the future world we are objectively richer, even if the good G still represents the same unit as today, in reality this loss of opportunity will objectively be smaller. Two factors susceptible of making the relative valorization of the flow evolving can be identified\textsuperscript{16}: the balance between offer and demand and wealth. Wealth, endogenous, is proper to every individual and therefore evolves according to the viewpoint adopted. On the other side, the balance between offer and demand can be considered as exogenous.

The effect of wealth is modeled in Ramsey’s equation, so this dimension is already taken into consideration by the temporal discounting. Remains to be broached the exogenous factor, the offer demand balance. At this stage, and in order to avoid getting into a microeconomic modeling, it is tempting to rely on known data, macroeconomic (growth) or sector based (sector growth) in order to characterize flows in a systematic and uniform way. One of the difficulties in that growth doesn’t exactly translate an appreciation of the unit value, but it also adds a notion of production (quantitative). This is why the consultant will use the growth indicator in order to characterize both qualitative and quantitative profiling of flows, in particular in order to point out the evolution of vulnerability (see previous paragraph).

To what extent is there an interest into using global growth rather than sector-based growth for each type of flow? This last approach can be justified if the sector growth of a cost or of a profit presents a huge gap with the global growth\textsuperscript{17}. In this last situation, a premium (positive or negative) could be applied to the current global growth highlighting the specificity of the sector.

The profits, damages avoided, are composed of direct and indirect costs. The latest, based on working days, are well represented by the actual growth. Indeed, there is no reason to think that only one part of economic actors, not representative of the basket of goods and services produced, should be affected by the disasters. Direct costs are more in relation to real estate and construction sectors whose respective growth can result either/both from size (scale) and/or « intensity » (unit price); it is possible to anticipate that these two provide overall a growth bigger than the average growth of the economy, at least until 2030, maybe even 2050. Beyond

\textsuperscript{16} We will suppose them sufficient to characterize flows.

\textsuperscript{17} We can legitimately object that a given sector can be in extensive growth with decreasing prices, as it is the case for NTIC this last decade for instance. Nevertheless, we consider that the considered sectors are less exposed to this type of behavior and that given the quantity and the long term horizons, an average effect makes it acceptable to use growth or sector growth averages.

\textsuperscript{12} The implicit hypothesis is the transcription at the more global scale of a town, unlike the A1B scenario. It is though necessary to beware as the inertia of towns and real estate will probably induce both a gap and collapse between the demographic variable and that of vulnerability.

\textsuperscript{15}Some profits have been directly projected to 2030 horizon (see phase 1).
the population could decrease. In phase 1 the consultant distinguished between building and field value and speculated on their respective profile over time. A premium of 1% for ten years has finally been considered, hence around 0.5% in a 20 years horizon. The direct cost of phase 1 shall here be consistently considered, being the profits of phase 2, when they correspond to building value, 0.5% of premium (on the direct costs part of the avoided damages only) above global growth over 20 years and after 2030 only half of that ‘vulnerability premium’ (conservative principle). That defines $\alpha^*_F$, the coefficient for profit profiling.

Costs, that after all include a large basket of goods and services, can also be correctly related only to the global economic growth (average effect). That defines $\alpha^*_F$, as the coefficient for cost profiling.

Remains to be fixed the economic growth’s profile, on which the flows are based. We can rely on the results of phase 1, but until 2030 only. Beyond, the only constraints are the consistency with the A1B scenario and the terms of choice presented on order to fix the minimum level y (see temporal discounting in 1.4.1). This is too partial information in order to lead to a set profiling of the economic growth. This is problematic, as on far horizons, the temporal discounting profile is strongly decreasing; therefore an ‘uncontrolled’ growth of the flows on a long period could lead to unexpected and sometimes unrealistic results. The sensitivity of the common ratio on its geometric progression is too important for not having a minimum level of confidence in it. But no theoretical tool or observation can enable such insight. The solution will be more pragmatic and experimental. Annex 1 makes state of this research, which also includes the $\alpha^*_C$, parameter defined above. This exercise leads to propose the following profile of global growth rate $\alpha_F$: +4% between 2010 and 2030 and +2% between 2030 and 2050. As explained in annex 1, it is wise to reduce the horizon to 40 years.

By those means, if the different measures proposed according to j and years according to i are indexed, each annual flow is calculated as follows:

$$F_{i,j} = B_{i,j} \left[ (1 + \alpha^*_C)^i (1 + \alpha^*_F)^j - C_{i,j} (1 + \alpha F_i) \right]^j$$

Phase 1 gives an image of $B_{i,0\alpha}$, temporarily discounted. The calculation of $B_{i,\alpha}$ can simply be derived by taking out the cumulated real estate premium (see phase 1) on the part of direct costs.

1.4.3 Indicators

In a first part, the consultant will associate a horizon to each quantified measure (with the limit of 40 years) and will calculate the associated NPV (measures are indexed on j, others coefficients are explained previously):

$$NPV_j = \sum_{i=1}^{H} F_{i,j} \frac{(1 + t)^{-i}}{\gamma}$$

with $F_{i,j}$ as defined in I-4-2 (previously).
To compensate the fact that each measure has its own horizon, eventually superior to 40 years, the consultant will only count as initial investment only a part of the real investment equal to the prorata of the 40 years horizon, compared to the measure’s life expectancy. A measure of 80 years of life will suffer from a cut to half of its initial investment.

The B/C ratio of benefits to costs (discounted) will also be calculated, in order to measure the efficiency of each unit invested. If relevant, the measures will be then placed in decreasing order according to B/C\(^{19}\) indicating the present value of benefits, this way giving both a quantitative and qualitative vision of the measure. The Internal Rate of Return (IRR) will also be provided, but beware that this indicator can be misleading in some cases (see Levy, WB). To assess investment efficiency we shall rely primarily on B/C.

Finally, if relevant, a calculation of the NPV is proposed, of the profits and of the B/C on the whole set of measures proposed over 40 years (sum on \(j\)). Let us remark that it is possible to add several NPVs having different horizons.

### 1.4.4 Calculation of cumulated damage

Equipped with the methodology exposed above, it is possible to propose a calculation of the present value of the total damages considered (those quantified, i.e. earthquakes). It is an improvement to this attempt that was undertaken in phase 1 in rougher terms.

The array bellow provides the NPV (in million EGP) of total damages for the range in which \(x\) varies for 20 and 40 years horizon; this also represents the base for benefits of adaptation measures:

<table>
<thead>
<tr>
<th>(x)</th>
<th>NPV (2010-2030)</th>
<th>NPV (2010-2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4%</td>
<td>14,285</td>
<td>29,796</td>
</tr>
<tr>
<td>5%</td>
<td>12,938</td>
<td>25,213</td>
</tr>
<tr>
<td>6%</td>
<td>11,768</td>
<td>21,504</td>
</tr>
<tr>
<td>7%</td>
<td>10,748</td>
<td>18,485</td>
</tr>
<tr>
<td>8%</td>
<td>9,856</td>
<td>16,019</td>
</tr>
<tr>
<td>9%</td>
<td>9,073</td>
<td>13,993</td>
</tr>
<tr>
<td>10%</td>
<td>8,384</td>
<td>12,319</td>
</tr>
</tbody>
</table>

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\(^{19}\) One problem can theoretically appear in this reasoning: each NPV is calculated individually without taking into consideration the other measures. But the addition operation requires a simultaneous management of the different options which can modify their NPV.

Indeed, those are determined according to reference scenario (BaU) not taking their application into account. We should then talk about conditional NPV... It should theoretically be possible to adopt a method such as the following:

1. Calculation of B/C (or any other investment efficiency indicator) for the \(n\) measures;
2. Choose the measure which maximizes the chosen indicator;
3. Calculate indicators for the \(n-1\) measures taking into consideration the application of the first measure identified as the most efficient;
4. Go back to 1

If simple in the concept, the major inconvenience in this method is the level of effort required.
This is somehow consistent with phase 1 figures although somewhat bigger; indeed phase 1 figures were ranging between 4,955 and 7,612 MEGP until 2030. Below is a more continuous representation of cumulated damages, expressed in absolute terms (MEGP) and also against the current GDP.
It appears that over a 20 years horizon, damages ranges between 8% and 15% of the current GDP. Over 40 years, the values spread significantly depending on the chosen initial rate (x). For the reference rate (x=7%), cumulated damages over 40 years for the BaU scenario slightly exceeds 18,000 MEGP or 20% of GDP.

2. Calculations and Results

The discounting methodology is set in the foregoing. In this section it is applied to the earthquake adaptation option. Only tangible and measurable benefits are counted. Recommendations for further studying do not bring on their own effective damage reduction but rather valuable information. As such, they cannot be counted as costs. They anyway do not amount significantly to overall required structural investments.

According to the technical expert in charge of geological hazards, the main adaptation option consists in upgrading buildings to the D standard (in reference to the EMS 98 nomenclature). This represents an extra cost of 10% for new buildings and 30% in the case of retrofit. The idea though consists more in saving lives before the structures totally collapses. These are difficult undertones to account for within the analytical framework it is relied on (cf. phase 1). For this reason, this option, as far as retrofit is concerned, has more to do with selected key buildings.

This links to another methodology challenge, whether new or retrofit: how to evaluate costs and benefits without knowing precisely the extent of the option? The question can perhaps be reformulated as follows: for a given available earmarked amount of funding, and a given economic efficiency, how many buildings can we afford to retrofit or build with improved seismic resistance?

This question calls for issues beyond the perimeter of this study. Indeed, the amount available are not depends on the underlying funding mechanism. If this is a public investment, it calls for public finance management. If the state however decides to have a normative approach, like it was the case in Turkey for e.g., then the extra cost is transferred to other stakeholders, such as property owners, or renters, with possibilities to think of mechanisms to diminish inequalities. These are political considerations, indeed out of the consultant’s sight at the moment. But, if values are used arbitrary, the consultant will provide with economic data that can feed debate about that. Indeed, the efficiency indicator, B/C, is invariant over any scaling factor applied to B and C. Definitely, here the most relevant indicator is B/C rather than the NPV.

Investment in this area shall be set to an equivalent of 5 years of the corresponding AAC calculated in phase 1, hence almost 3,000 MEGP. As the horizon though is 40 years whereas the building life expectancy is bigger – let us say 100 years, only 40% of the total facial investment will be counted, hence 1200 MEGP.

The consultant also makes the simple assumption that all the investment is done once at the beginning of the considered period. Once a clearer line is defined in this area, it is probably wise to restart the exercise with a more detailed and realistic vision of investment phasing.

If phase 1 data that details building distribution along the EMS 98 typology are used, it is possible to figure out that the average building is of class C or minor D. After repeated sensitivity tests, a rather optimistic value has been considered for potential savings on AAC; The ratio is close to 0.03% per surface unit, including indirect costs. This is a pretty low value, nowhere close to allow an acceptable economic performance as shown below.
The price per square meter averaged by relevant surfaces is slightly bigger than 9 kEGP. If only the building value is accounted for, it comes to 5 kEGP (ref. to relevant ratio in phase 1). Assuming 80% of the investment in new buildings and 20% for retrofit, a 14% base is obtained. Accounting for the difference of horizon and life expectancy and a real estate premium of 30% (conservatism) for new buildings, a cost slightly bigger than 200 EGP/m² is obtained, where the benefit is slightly below 0.2 EGP/m² (using above mentioned ratio).

The cash flow discounting as per the methodology proposed gives the following results (in MEGP for NPV and dimensionless for B/C):

<table>
<thead>
<tr>
<th>x</th>
<th>NPV</th>
<th>B/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>4%</td>
<td>-1.141</td>
<td>0.03</td>
</tr>
<tr>
<td>5%</td>
<td>-1.146</td>
<td>0.02</td>
</tr>
<tr>
<td>6%</td>
<td>-1.149</td>
<td>0.02</td>
</tr>
<tr>
<td>7%</td>
<td>-1.152</td>
<td>0.02</td>
</tr>
<tr>
<td>8%</td>
<td>-1.155</td>
<td>0.02</td>
</tr>
<tr>
<td>9%</td>
<td>-1.157</td>
<td>0.02</td>
</tr>
<tr>
<td>10%</td>
<td>-1.158</td>
<td>0.01</td>
</tr>
</tbody>
</table>

With a largely negative IRR (-10%), and costs exceeding 50 times benefits in average, this option is not viable under the analytical framework developed. The NPV is very low and almost equal to equivalent investments over the considered horizon (not the facial ones).

Overall this difference in risk translates to a very low impact compared to required investment. This is somehow an opportunity to credit current average building standard in Alexandria, whose level is close to recommended ones. Still, these figures talk globally and averagely and it might well be that a more detailed spatial analysis identifies areas of strong discrepancies where economic efficiency of investment is much higher.
Impact of the proposed measures on health

The flow discounting in the sector of health gives the following results:

<table>
<thead>
<tr>
<th>x</th>
<th>4%</th>
<th>5%</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV (MEGP)</td>
<td>5 653</td>
<td>4 604</td>
<td>3 771</td>
<td>3 106</td>
<td>2 575</td>
<td>2 149</td>
<td>1 806</td>
</tr>
</tbody>
</table>

The impacts of climate change on health have been, during phase 1, taken out of the economic analysis perimeter from consistency matters. Indeed, for the three sites studied, it has been possible to propose and evaluation of costs imputable to climate change in terms of health. But for all the others considered disasters, the calculated damages include climate change but that constitutes one small part only of the disaster costs. The key characteristics in this thematic and in the proposed approach should also be acknowledged:

- Calculations have been made on the basis of a recent literature and still relatively not explored (Ebi, see phase 1). To the consultant’s knowledge there is no accessible or adapted data that would enable to quantify the benefits on health of the chosen measures and this is mainly because their first objective doesn’t concern this sector.
- The perimeter of costs chosen for the disasters doesn’t include health aspects (see phase 1 and conservative principle).
- Measures avoiding damages of this kind would hardly be valued in the established analytic frame.

Measures that can have an impact on health are of two kinds: specific measures to the health sector and measures having an indirect impact on health. The former do not form part of the perimeter of this study, the team not benefiting from an expert in the subject; in order to develop an established argument in this field, it would be better to dispose of the capacity of building investment scenarios and of sector policy.

As for the indirect measures, they concern the energy efficiency, bioclimatic comfort and water quality. This last point is only briefly broached, and it has been shown (phase 1) that water management as a resource was linked to issues well beyond the sole urban perimeter (to which the consultant is confined for this study); nevertheless it was shown that the related costs were low compared to other considered hazards. Concerning the bioclimatic comfort and the energy efficiency, the measures proposed remain at a very general level. The calculation of costs would require here again defining the corresponding BaU, which is actually a matter of national and regional energetic strategies.

There is one particularly reassuring element to the fact of remaining at such a general level. Indeed, those measures are known for being already highly profitable from the sole energetic point of view. As elaborated would be the calculations in this field, the result is already known, without great precision but in a qualitative way: the B/C would be superior to 1 as the whole literature and practice amply demonstrate it, as long as energy is valued to its real cost, not to its state subsidized cost; this approach is the one that has to be taken in the frame of the present exercise (global costs). We therefore are clearly facing no regrets measures in this field: the health profits, even if hardly measurable, constitute additional profits to already viable measures which then appear as even more opportune.
3. Conclusion

In the study of most risks in Alexandria, the consultant is in a somehow particular position, in the sense that the study as conceived cannot allow quantified modeling for all hazards under the scope. If referring to the first figure (cf. 1.1 of the present chapter), we mostly lie in the yellow area, i.e. decision making cannot rely on quantified indicators. It therefore requires a particular effort to adapt the economic contribution to available set of data.

The quantified part of the economic analysis focuses on three main topics: discounting, earthquake cumulated damages and evaluation of proposed adaptation option, and cumulated damages of climate change on the health sector.

Discounting is a fundamental yet difficult part of the economic analysis, especially as far as general interest is concerned, over long time range. The framework developed is applied to earthquake adaptation and cumulated damages on health of climate change. But it goes really beyond the scope of this study and can inspire approach for many other similar decision making processes. It is definitely possible to capitalize on this framework based on current state of the art economic techniques. Further it allows refining the calculation of cumulated damages of quantified disasters proposed in phase 1: a total amount of 18,000 MEGP or 20% of the current GDP is obtained, over a 40 years horizon for earthquake activity only.

The earthquake adaptation option proved not to be economically viable in the framework developed. There are three factors to account for that result: first of all, the level of hazard is not very high: all events were considered to occur at level VI on the intensity scale provided. Secondly, the consultant did not account, as it was the case for Tunis, of softer grounds that tends to amplify effects of a given vibration (intuitively energy is diffused rather than propagated). Thirdly, the present methodology assesses an option not as such but against a current vulnerability baseline. That baseline tends to be quite close to the objectives recommended (class D under the EMS 98 typology), hence the benefit is small compared to almost constant structural upgrading costs. The analysis of the low efficiency coefficient of this investment (close to 2% only, where viability is usually granted above 1) must not be disappointment. To the contrary, it reflects to a certain extent that on average reasonably good practices are used in Alexandria regarding construction standards, at least on this particular feature. It is also good news in the sense that at a given level of funding available to fight disasters, the share for earthquake should be pretty low, and hence money can be affected where more useful.

The cumulated damages of health are also calculated according to the discounting methodology established: over 40 years its NPV slightly exceeds 3,000 MEGP. The study perimeter does not encompass health adaptation options hence it is not possible to calculate direct benefits of dedicated health options. It is also not possible to quantify indirect effect on health of measures proposed, such as developing more energy efficient building codes and / or bioclimatic comfort criteria in urban architecture, or improving water services and integrated management. It must be understood that health is a highly complex field and that unless dedicated expertise and important means are earmarked on these topics, it is inappropriate to develop quantitative argumentation on benefits. Luckily though, it should be acknowledged that this limitation is not to jeopardize decision making. The reason is simple: these investments are known, as such, to be very much efficient. Indeed, they generate considerable energy savings. As long as energy saving is valued to its real production price (hence excluding
subsidies), it is already viable as such; then no big matter if further benefits (on the health sector) cannot be quantified. From that perspective, these investments can be categorized as “no regret” ones.

It is somehow delicate to develop a point of view on the non quantified part that encompasses all other hazards under scope. It is tempting to extend or adapt what could be said with more certainty on the two other sites of the study (Tunis and Casablanca). We shall however remain prudent in this attempt, since the results are built upon a baseline that is particular to each site. Still, without prejudging on results of future more focus studying of these different hazards on Alexandria or parts of it that should be hold, the consultant can expose some of the lesson learning we think might hold to Alexandria as well. Indeed, when some adaptation options have shown very high level of economic efficiency on the two other sites, it is believed it can be thought the result might also hold for the somewhat similar context of Alexandria.

In this perspective, it emerges that early warning systems, including both ascending and descending alerts, are a very wise investment. This is simple to figure out: investment is relatively small where base for benefits is huge (all disasters are concerned).

Also, coastal investments proposed are usually very profitable, even though the impact a somewhat smaller base. Coastal management in that perspective also seems to be a “non negotiable” investment.

As far as water management and flooding management are concerned, things are less conclusive, and depend more on the site. And, on each site, there seems to be stronger variations in spatial distribution. Infrastructures are always expensive, but the base they impact on is also huge. Whether benefits overwhelm cost or not can hardly be guessed in general terms but require more dedicated and site specific studying. On the other hand, in that case there are quite straightforward ways of financing. Original approaches such as backing urban infrastructure development on real estate rise in value seem to be a promising lead (see Peterson, WB). Integrated water management, with green areas that can be used as natural buffers inter alia also have a huge potential of effect, but the cost opportunity is difficult to contemplate from the sole economic perspective. It seems that that level of complexity is often better dealt with a political or social approach. Last, on site measures to reduce vulnerability are usually economically profitable, but for selected areas only (roughly the extended flooding area).

It is a situation in which investment opportunities look appealing. Nonetheless it is important to highlight to the managers of the considered zone that some measures could have appeared more profitable but the fact that the reference scenario has a certain sturdiness largely contributed to the limitation of the perimeter of new actions.

Furthermore, we know that the infrastructures are particularly expensive, especially that to retrofit. Hence a big part at stake lies in the new ones and therefore the understanding and action on present and future dynamics. The EGP invested in this area is marginally more profitable that in the ‘old town’, even if this one keeps a very important symbolic value.

Resilience will also be expressed in more various forms such as airming of the town (buffer zones, diminution of run off); the intensity of the verticalness is also to be considered. In this context, very soon the following question is raised: to what extent continue urban expansion? It can then be interesting to slow it down and to organize the development of new urban hubs. In such optic, the thematic of transportation comes back to the foreground. It is also possible to argue for more urban continuity, in return of less densification, therefore guaranteeing more green spaces per inhabitants for instance. No matter what, it imposes to the planners of Alexandria a reflection on regional and national scales.
The quantitative approach on the economic part as a support to decision making is interesting for various reasons: it appears more objective and more innovative, as this type of exercise is complex and not widespread. Let us remind that the question guiding the present approach (see the phase 1 report): “From the risk management point of view, do we have to limit to an urban planning policy based on the reference scenario (BaU) or is it better to consider (one) alternative(s) improving it, and if yes, which one(s)?”

Concrete elements of answer to this question have been brought in the frame of analysis previously exposed. Once this important point dealt with, and out of the legitimate questionings concerning methodological choices or uncertainties, some other interrogations remain before being able to consider, according to the Consultant, definitive operational choice related to economic or financial matters:

- The question of the opportunity of a certain number of actions is evaluated positively. But as it is often the case for a great number of initiatives (building of schools, health expenses, etc...), it is not a sufficiently discriminatory criteria; rather a necessary condition.
- Before opting concretely for the proposed options, it should be wise to face them to the direct competition of other projects also generating value ; the number of projects adopted in the end will depend (among other things) on the total of available financing.

This requires dealing with two more questions:

1. **What is the financing model, what roles do public and private actors play, what is the source of the capital and loans (sovereign, semi-sovereign, commercial)?**

On this point it is clear that the loan rates are extremely sensible to the nature of the investor as well as to the general macroeconomic context. The rates will also depend on the projects themselves, and even more if private actors are involved.

Besides its cash flows, the capacity that the project offers in terms of collateral and other guarantees will have its importance: other things being equal, a project proposing additional guarantee should benefit from more favorable borrowing conditions. The sequencing of financing will also have an impact on the rates; first at the scale of the project: for a similar flow dedicated to debt payment, the latest creditors take more risks hence usually require higher remunerations; second at a more global scale: as investment grows (and so does borrowing) financing conditions evolve; it is then to anticipate that the marginal cost of money will go crescendo.

2. **What is the reimbursing model? Indeed, if it can be legitimate to count as gain an absence of loss in order to judge an opportunity like the one considered in this study, this doesn’t solve the issue of effectively securing the corresponding funds.**

To illustrate this point, should a flood of a given return period be without effect thanks to a more efficient draining system, still no bank account would actually be credited of the worth of the avoided damages. It is then necessary to consider a source of revenues dedicated to finance such an investment: general or specific taxes, insurance obligation, etc... It is important to note that collecting a cash unit requires an administrative structure, which has also a cost. It is agreed to account for this « friction force » as well, more commonly known as public funds opportunity cost (ranging between 1.1 to 1.5 in Europe depending on the efficiency of the tax system-see also Bouinot, 2007).
The putting in place of robust financing and reimbursing models is obviously an essential step requiring consequent work. In this field that has been just partially broached here, it appears that some innovative options such as financing with real estate seem appropriated, both socially and economically (see Peterson).

In fine, this type of work enables to inform the decision makers of the nature of the existing equilibrium in terms of allocation of means and possible results from one side, and of the opportunity of financing this or this sector on the other. The present study stops before an opportunity study specifically linked to the Egyptian public financing. The main reason is that the means for this study are not sufficient to enable a different nature or a wider volume to the research.

There exists an advantage to the developed approach: what is lost in specificity is won in global understanding, with a certain capitalization and transposition capacity. To a certain extent, the study as conceived enables the comparison between different North African sites or other towns, or moreover on the thematic of natural disaster management and adaptation to climate change. This last investigation range is relatively new and yet not too tagged which would make it understandable if the chosen approach would favor the added value of a general capitalization to a specific operational decision for a single site only.

It must be emphasized that the present study only touches slightly the socio-economic consequences of climate change on affected areas, which concern the potential proposed cost of allocation of people and the cost of loss of economic activities in the affected areas by 2030 (in the form of agricultural land, industrial buildings, etc.) and how this might impact Egypt's national economic status by 2030. Also, no action plan has been proposed for the assessment of the people's willingness to accept or willingness to pay for reallocation in case of confirmed environmental risk or seismic-prone buildings, for e.g. is Sinai a potential area for reallocation? What other areas can be identified as having capacities to accept environmental refugees? What would costs of allocation be? All these questions definitely deserve answers in subsequent studies.

Similarly, a detailed survey for economic activities is needed for vulnerable areas to assess the economic impact of climate change and disasters (floods, earthquakes, etc.) and their likely impact on the national economy, as an important stage in determining possible mitigation measures that may be needed to counter-effect or protect these economic sectors.
1. Principles

Following the definition in Chapter 5 of the main recommendations to reach the protection objectives against natural disasters and climate changes, and the provision in Chapter 6 of economic considerations, the present chapter aims to select and classify the most relevant and urgent recommendations with respect to identified stakes and expected benefits.

The purpose is to establish a progressive and realistic intervention programme of the actions to be carried out, taking into account the human and material means required for their implementation and the related costs.

Several intervention scenarios could be drafted, considering the various assumptions, the priority level of the actions, their cost, and phasing possibilities, each scenario being a specific combination of recommendations. However, rather than selecting actions to define scenarios, it is considered more relevant to propose a « programme », involving all actions organized according to a given schedule.

The intervention programme could be structured in two successive phases:

- A short term programme (5 years), encompassing the first priority actions, which would constitute a quinquennial plan. Within this first plan, the most urgent measures – to be implemented during the first two years – could be distinguished from other recommendations.

- A medium term programme (10 to 15 years), for actions deemed less urgent and/or requiring financial investments likely to exceed the short term funding capabilities.

It is important to highlight at this point that adjusting the programme by shifting actions from one phase to the other is quite easy. The present programme therefore provides a great range of choice to the Egyptian authorities, according to their ambitions and capacities.

In terms of strategy, the action plan presented hereafter reflects a preference for « no regret » actions (useful and efficient even without climate changes), flexible actions (e.g. urban planning), and low cost actions (regulation, institutional measures …). Acquiring knowledge also remains a priority, as most of the recommendations require in-depth knowledge on risks and vulnerabilities, before their effective implementation.
2. **Schedule**

The action plan is presented in a **table summarizing all proposed recommendations**, with an emphasis on:

- the level of risk (stake) related to these actions on the 2030 horizon, as estimated in the Phase 1 study report,
- efficiency (cost/benefit ratio) of these actions, as estimated through the economic analysis,
- the proposed schedule for their implementation,
- the initial investment cost and the maintenance or monitoring costs for the considered period, as far as providing rough assumptions was possible.

**Remarks on the schedule**

- The scheduling mainly depends on the level of risk and efficiency of the recommendation. Costs are shown for information.
- Recommendations are classified by type of risks, then by intervention strategy. However, the reverse situation would be also relevant.
- The level of risk is presented in the Phase 1 report (see the last column in the synthesis table).
- Efficiency is an expert opinion, supported by the economic analysis. Preference is given to actions allowing a multi-risk approach. The assessment is qualitative, expressed in a scale of three categories: +, ++, +++.
- The scheduling concerns investments and works to be carried out, except when recommendations only deal with studies. All the recommended studies must be conducted during the 1st phase (short term). In this first phase, the most urgent recommendations – to be implemented during the first two years (XX) – are distinguished from the other recommendations (X)
- Cost: the term “≈ 0” means that the cost is nil or negligible; “?” means that the cost cannot be estimated without further studies.
- Other information is contained within the table to aid comprehension of the potential priorities and synergies:
  - Type of action and sector concerned: with reference to the spheres of intervention Infra. = Infrastructure/technical measure; Urban = Urban planning/regulation; Institu. = Institutional/operational/training/awareness building preparation. Remember that the recommendations are classified in one of three spheres, but some may be related to 2 or even 3 of the spheres at once.
  - Scale of intervention: local (town/city districts or drainage basins), regional (Greater Alexandria), national. In principal, the more extensive the scale, the more significant the issue.
> Programmes in progress: the recommendation has even more chance of being considered and implemented if it can dovetail with certain programmes in progress.

> Links with other recommendations: enables the extent of the actions' global and cross-disciplinary nature to be identified.

Though it is not part of the scope of the present study, some elements regarding financial mechanisms to support the implementation of the action plan are provided in the conclusion of the economic analysis (see Chapter 6).
### Action Plan Schedule

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Action Type</th>
<th>Scale of intervention</th>
<th>On-going Programs</th>
<th>Links with other actions</th>
<th>Risk level (stake)</th>
<th>Efficiency</th>
<th>Cost 10^6 EGP</th>
<th>Scheduling</th>
<th>Cost 10^6 EGP</th>
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<tbody>
<tr>
<td><strong>Multiple Risks Management</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>1 – Improvement of institutional coordination for natural disaster preparedness and climate change adaptation</td>
<td>Institu.</td>
<td>National / Regional</td>
<td>No</td>
<td>Sheets 2, 20, 26</td>
<td>High</td>
<td>+++</td>
<td>≈ 0</td>
<td>≈ 0</td>
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</tr>
<tr>
<td>2 – Strengthening the monitoring and early warning system</td>
<td>Institu.</td>
<td>National</td>
<td>Yes</td>
<td>Sheets 1, 3, 7, 8, 10, 13, 15, 18, 20</td>
<td>High</td>
<td>+++</td>
<td>?</td>
<td>?</td>
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<tr>
<td>3 – Preparation and self-protection against fast-impacting phenomena</td>
<td>Institu.</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 2, 4, 5, 10, 13, 18, 20</td>
<td>High</td>
<td>+++</td>
<td>?</td>
<td>?</td>
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<tr>
<td>4 – Future mechanism for natural risk insurance</td>
<td>Institu.</td>
<td>National</td>
<td>No</td>
<td>Sheets 3, 5, 6, 12, 15, 18, 24</td>
<td>High</td>
<td>+</td>
<td>≈ 0</td>
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<tr>
<td>5 – Implementation of building and urban regulations</td>
<td>Urban</td>
<td>National</td>
<td>Yes</td>
<td>Sheets 3, 4, 6, 7, 8, 9</td>
<td>High</td>
<td>+++</td>
<td>14.5</td>
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<tr>
<td>6 – Integration of Climate Change Adaptation and Mitigation Measures in an Urban Management Mechanism</td>
<td>Urban</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 4, 5, 9, 11, 21, 26</td>
<td>High</td>
<td>+++</td>
<td>12</td>
<td>≈ 0</td>
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<tr>
<td>7 – Proactive measures for protecting the urban population prone to natural disasters: Abu Quir Area</td>
<td>Urban</td>
<td>Local</td>
<td>No</td>
<td>Sheets 2, 5, 8, 12, 19, 23, 24, 25</td>
<td>High</td>
<td>++</td>
<td>5 000</td>
<td>≈ 0</td>
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<tr>
<td>8 – Proactive measures for protecting the urban zones prone to natural disasters: El Max Area</td>
<td>Urban</td>
<td>Local</td>
<td>No</td>
<td>Sheets 2, 5, 7, 12, 18, 23, 24, 25</td>
<td>High</td>
<td>++</td>
<td>2 000</td>
<td>≈ 0</td>
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<tr>
<td>9 – Piloting a climate change risk sensitive urban plan for a new expansion area in the city of Alexandria</td>
<td>Urban</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 5, 6</td>
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<td>++</td>
<td>3 000</td>
<td>≈ 0</td>
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<td>Recommendations</td>
<td>Action Type</td>
<td>Scale of intervention</td>
<td>On-going Programs</td>
<td>Links with other actions</td>
<td>Risk level (stake)</td>
<td>Efficien- cy</td>
<td>Scheduling</td>
<td>Cost 10^6 EGP</td>
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<td><strong>Management of Ground Instability / Seismicity</strong></td>
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<tr>
<td>10 – Develop the earthquake recording and surveillance system</td>
<td>Institu.</td>
<td>National</td>
<td>Yes</td>
<td>Sheets 2, 3</td>
<td>Medium</td>
<td>+</td>
<td>X</td>
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<td>2</td>
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<tr>
<td>11 – Carry out seismic microzoning on Alexandria and take it into account in the urban development plans</td>
<td>Urban</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 6, 12</td>
<td>Medium</td>
<td>+</td>
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<td>3</td>
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<tr>
<td>12 – Assess the seismic vulnerability of existing buildings in Alexandria</td>
<td>Infra.</td>
<td>Local</td>
<td>No</td>
<td>Sheets 4, 7, 8, 11</td>
<td>Medium</td>
<td>++</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
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<tr>
<td><strong>Control of Coastal Erosion and Marine Submersion</strong></td>
<td></td>
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<td></td>
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<tr>
<td>13 – Set up a tsunami downward warning system</td>
<td>Institu.</td>
<td>National</td>
<td>Yes</td>
<td>Sheets 2, 3, 15, 18</td>
<td>Low</td>
<td>++</td>
<td>X</td>
<td>≈ 0</td>
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<tr>
<td>14 – Improve knowledge on tsunamigenic sources</td>
<td>Infra.</td>
<td>National</td>
<td>No</td>
<td>Sheet 15</td>
<td>Low</td>
<td>+</td>
<td>XX</td>
<td>?</td>
<td>≈ 0</td>
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<tr>
<td>15 – Local zoning of the tsunami risk and damage scenarios in Alexandria</td>
<td>Infra.</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 2, 4, 13, 14, 18</td>
<td>Low</td>
<td>+</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
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<tr>
<td>16 – Improve knowledge on the changes of coastal beaches (excluding the Corniche road)</td>
<td>Infra.</td>
<td>Local</td>
<td>No</td>
<td>Sheet 17</td>
<td>High</td>
<td>++</td>
<td>XX</td>
<td>2.2</td>
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<td>17 – Improve knowledge on the changes of the beaches along the Corniche road</td>
<td>Infra.</td>
<td>Local</td>
<td>No</td>
<td>Sheet 16</td>
<td>Medium</td>
<td>+</td>
<td>X</td>
<td>4</td>
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<tr>
<td>18 – Preventing sea submersion risks of the Alexandria coastline</td>
<td>Infra.</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 2, 3, 4, 8, 13, 15, 19, 20</td>
<td>Medium</td>
<td>+</td>
<td>X</td>
<td>8.1</td>
<td>≈ 0</td>
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<tr>
<td>19 – Preventing sea submersion risks in the Abu Quir Bay</td>
<td>Infra.</td>
<td>Local</td>
<td>No</td>
<td>Sheets 7, 18</td>
<td>High</td>
<td>++</td>
<td>XX</td>
<td>0.1</td>
<td>≈ 0</td>
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<tr>
<td>Recommendations</td>
<td>Action Type</td>
<td>Scale of intervention</td>
<td>On-going Programs</td>
<td>Links with other actions</td>
<td>Risk level (stake)</td>
<td>Efficien- cy</td>
<td>Scheduling</td>
<td>Cost 10^6 EGP</td>
<td></td>
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<tr>
<td><strong>Flood Control</strong></td>
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</tr>
<tr>
<td>20 – Early warning system, emergency plans and public awareness</td>
<td>Institu.</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 1, 2, 3, 18, 24</td>
<td>Medium</td>
<td>+++</td>
<td>XX</td>
<td>20</td>
<td>≈ 0</td>
</tr>
<tr>
<td>21 – Control runoff discharges in future urbanized areas and in urban renewal programs</td>
<td>Urban</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 6, 22, 23, 24, 25</td>
<td>Medium</td>
<td>+++</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
</tr>
<tr>
<td>22 – Enhancement of the current protection level against floods and Master Plan update</td>
<td>Infra.</td>
<td>Regional</td>
<td>Yes</td>
<td>Sheets 21, 23, 24, 25, 26</td>
<td>Medium</td>
<td>++</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
</tr>
<tr>
<td>23 – Control and reduction to runoff discharges in existing urban areas</td>
<td>Infra.</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 7, 8, 21, 22, 24, 25</td>
<td>Medium</td>
<td>+</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
</tr>
<tr>
<td>24 – Manage floods in urban areas</td>
<td>Infra.</td>
<td>Regional</td>
<td>No</td>
<td>Sheets 4, 7, 8, 20, 21, 22, 23, 25</td>
<td>Medium</td>
<td>++</td>
<td>XX</td>
<td>≈ 0</td>
<td>≈ 0</td>
</tr>
<tr>
<td>25 – Cleaning and maintenance program of the sewage combined network</td>
<td>Infra.</td>
<td>Regional</td>
<td>Yes</td>
<td>Sheets 7, 8, 21, 22, 23, 24</td>
<td>Medium</td>
<td>++</td>
<td>XX</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Water Scarcity Management</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>26 – Control and optimization of water consumption</td>
<td>Institu.</td>
<td>National</td>
<td>Yes</td>
<td>Sheets 1, 6, 22, 27</td>
<td>High</td>
<td>+++</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
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<tr>
<td>27 – Reuse treated wastewater and sludge</td>
<td>Infra.</td>
<td>National</td>
<td>No</td>
<td>Sheet 26</td>
<td>High</td>
<td>+++</td>
<td>X</td>
<td>?</td>
<td>≈ 0</td>
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</table>
3. Structuring the Action Plan and Definition of Priorities

In addition to the action plan schedule an analysis chart is provided which aims to highlight the synergies between actions and the way in which they complement each other, and therefore the way in which they join up within the programme. By doing this, the idea is also to highlight the priority action groups, by differentiating:

- the actions deemed to be most effective and those that when implemented condition the effectiveness or the feasibility of other actions (upstream actions) and a contrario
- the least effective actions (because they are not linked to a major issue or have limited effect) or the effectiveness of which is strongly dependent on other actions (downstream actions).

The analysis chart sets out a critical path which defines the hierarchical level of the actions, their degree to which they relate to each other, and the order in which they are to be implemented. Using this chart highlights the priority nature, in terms of scheduling, of the following recommendations:

1 – Institutional coordination for natural disaster preparedness and climate change adaptation
2 – Strengthening the monitoring and early warning system
3 – Preparation and self-protection against fast-impacting phenomena
5 – Implementation of building and urban regulations
11 – Carry out seismic microzoning on Alexandria and take it into account in the urban development plans
14 – Improve knowledge on tsunamigenic sources
16 – Improve knowledge on the changes of coastal beaches (excluding the Corniche road)
19 – Preventing sea submersion risks in the Abu Quir Bay
20 – Early warning system, emergency plans and public awareness
24 – Manage floods in urban areas
25 – Cleaning and maintenance program of the sewage combined network
## ACTION PLAN STRUCTURE

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Articulation with related actions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very short term</td>
<td>Short term</td>
<td>Medium term</td>
</tr>
<tr>
<td><strong>Multiple Risks Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 – Institutional coordination for natural disaster preparedness and climate change adaptation</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Strengthening the monitoring and early warning system</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – Preparation and self-protection against fast-impacting phenomena</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – Future mechanism for natural risk insurance</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 – Implementation of building and urban regulations</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>6 – Integration of Climate Change Adaptation and Mitigation Measures in an Urban Management Mechanism</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – Proactive measures for protecting the urban population prone to natural disasters: Abu Quir Area</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 – Proactive measures for protecting the urban zones prone to natural disasters: El Max Area</td>
<td>X</td>
<td></td>
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</tbody>
</table>
## Recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very short term</td>
<td>Short term</td>
<td>Medium term</td>
</tr>
<tr>
<td>9 – Piloting a climate change risk sensitive urban plan for a new expansion area in the city of Alexandria</td>
<td>X</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>10 – Develop the earthquake recording and surveillance system</td>
<td>X</td>
<td>2, 3</td>
<td></td>
</tr>
<tr>
<td>11 – Carry out seismic microzoning on Alexandria and take it into account in the urban development plans</td>
<td>X</td>
<td>6, 12</td>
<td></td>
</tr>
<tr>
<td>12 – Assess the seismic vulnerability of existing buildings in Alexandria</td>
<td>X</td>
<td>11</td>
<td>4, 7, 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Management of Ground Instability / Seismicity</strong></td>
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<td>X</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>13 – Set up a tsunami downward warning system</td>
<td>X</td>
<td>2, 3, 15, 18</td>
<td></td>
</tr>
<tr>
<td>14 – Improve knowledge on tsunamigenic sources</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>X</td>
<td>2, 14</td>
<td>18</td>
</tr>
<tr>
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<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 – Improve knowledge on the changes of the beaches along the Corniche road</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 – Preventing sea submersion risks of the Alexandria coastline</td>
<td>X</td>
<td>2, 3, 19, 20</td>
<td>15</td>
</tr>
<tr>
<td>19 – Preventing sea submersion risks in the Abu Quir Bay</td>
<td>X</td>
<td></td>
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### Recommendations

<table>
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<tbody>
<tr>
<td><strong>Flood Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 – Early warning system, emergency plans and public awareness</td>
<td><strong>X</strong></td>
<td>1, 2, 3, 18, 24</td>
<td>The same as action 2, but focusing on flood risks.</td>
</tr>
<tr>
<td>21 – Control runoff discharges in future urbanized areas and in urban renewal programs</td>
<td><strong>X</strong></td>
<td>24, 25, 6, 22, 23</td>
<td>It is understood that flooding issues are currently not at stake in Alexandria. However, one of the first actions to be implemented in this field is preventing any new discharges to flood prone areas from future urban areas.</td>
</tr>
<tr>
<td>22 – Enhancement of the current protection level against floods and Master Plan update</td>
<td><strong>X</strong></td>
<td>24, 25, 21, 23, 26</td>
<td>In order to accommodate future urban development, together with climate changes, assumptions considered in the current sewerage master plan have to be updated.</td>
</tr>
<tr>
<td>23 – Control and reduction to runoff discharges in existing urban areas</td>
<td><strong>X</strong></td>
<td>21, 22, 24, 25, 7, 8</td>
<td>May involve significant investments (retrofitting of the present network is expensive), without knowing if this action is cost effective.</td>
</tr>
<tr>
<td>24 – Manage floods in urban areas</td>
<td><strong>X</strong></td>
<td>20, 25, 4, 7, 8, 21, 22, 23</td>
<td>Regarding flood issues, the first priority is to address the present “black spots” in Alexandria, through this action.</td>
</tr>
<tr>
<td>25 – Cleaning and maintenance program of the sewage combined network</td>
<td><strong>X</strong></td>
<td>24, 7, 8, 21, 22, 23</td>
<td>This action is one of the most cost effective to improve the current situation regarding flood issues.</td>
</tr>
<tr>
<td><strong>Water Scarcity Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 – Control and optimization of water consumption</td>
<td><strong>X</strong></td>
<td>1, 6, 22, 27</td>
<td>There is currently no water shortage risk, so this action is not considered as a priority.</td>
</tr>
<tr>
<td>27 – Reuse treated wastewater and sludge</td>
<td><strong>X</strong></td>
<td>26</td>
<td>Refines the previous action with regard to wastewater recycling needs.</td>
</tr>
</tbody>
</table>
4. Implementation

The different recommendations of the action plan are under the responsibility of the government services and state organisations identified on each sheet. To coordinate the initiative and monitor the implementation of the different actions, it would be desirable to nominate a coordinating body. This could be the Egyptian Environmental Affairs Agency (EEAA), because of its role which is both central and cross-disciplinary as far as questions of natural risk prevention are concerned. Also, questions of climate change and particularly adaptation are in a position to be handled by them.

The EEAA will have to consult with the Ministries of Finance and Foreign Affairs in order to set out the financial arrangements for the project. It is in fact fairly unlikely that the Egyptian government will be able to finance all the actions out of its own funds, so some international aid will have to be requested. Multilateral development agencies and Egypt’s main economic partners could be approached. As soon as possible, these partners will be approached for the launch and financing of any additional studies required for the implementation of the action plan (drawing up of the ToR, launch of consultations, selection and coordination of the consultants). The operations to be launched first are those defined above as priority.

Around the EEAA, a coordination committee could be set up which brings together the financial partners and the main authorities concerned by the action plan: Information and Decision Support Centre, Civil Protection Administration, General Organization for Physical Planning, Alexandria Governorate, Holding Company for Water and Wastewater, Egyptian Meteorological Authority, Shoreline Protection Agency. Under the aegis of the EEAA, this coordination committee could meet every three months to review the progress of the action plan.

Lastly, the following recommendations make up a kind of project "memento". They recap the guiding principles of the action plan, within a strategy of effectiveness and progressiveness.

1. Begin with a strengthening of the institutional capability for the implementation of the action plan (see Chapter 8).
2. Focus on the measures that prevent irreversible situations relating to climate change, particularly represented by urban planning actions.
3. Establish synergies between the actions that reduce the risk and adapt to climate change and the economic development investments and policies that respond to the urgent and immediate needs of the population.
4. Clearly differentiate between short-term measures and long-term measures. In the short-term, until 2030, the most desirable adaptation measures are those that maximise the synergies with other political objectives like poverty reduction, competitiveness, or the conservation of natural areas.
5. Preserve however a certain flexibility in relation to the intervention priorities, in such a way that the financing available is taken into account.
6. Explore new financing methods (insurance, subsidies, taxes, etc.) and establish an incentive-based assistance system related to individuals and companies.
7. Communicate about the issue of natural disasters and climate change, with a mind to being transparent and increasing the awareness of the wider public.
Chapter 8 – Institutional and Operational Framework for the Implementation of the Action Plan

1. General Observations

The overall impact of natural risks (earthquakes, floods, landslides and storms) on Egypt in the last 60 years is well figured out by the number of casualties that ranges between 1400 and 1500.

With respect to most of the Mediterranean, African and Middle East countries, these figures point to a moderate-hazard region, whose top natural disasters impact is associated to the 1992, 5.3 Magnitude, Dahshour earthquake. Poverty has a role in this picture, as slightly less than 50% of the above casualty tribute comes from damage triggered by that earthquake on poorly maintained buildings: and another 12% comes from two relatively small rockfalls that buried two urban “informal settlements” in 1993 (Al-Zabalyn) and 2008 (Moqattam).

The study area of Alexandria suffered from the 1955 earthquake only, that was responsible for a few tens of casualties. Then, no comparison is possible between recent times and late-Roman and Middle-Age, with their deadly tsunamis of 365 and 1303, triggered by major earthquakes in the Hellenic Arc and the Alexandria-facing Crete, respectively.

The over 900 years elapsed between those large events - and the ca. 700 elapsed from the great earthquake of 1303 to date - testify of a major, slow-building hazard that has to be taken in due account when redrawing the urban asset of Alexandria, and attempting at securing its historical heritage and its future. On account of this evidence, all action for mitigating the whole of Major Natural Risks insisting on the Alexandria Region (a) should be projected into the mid-to-long term, and consequently (b) deal with Major Risks and Climate Changes at once.

No surprise therefore if, among the 27 technical sheets introduced earlier in this report, as much as 15 deal with earthquake, tsunami and coastal flooding vulnerability (Tables 10 to 25), whereas 6 deal with miscellaneous protection methods and initiatives, 2 with water management, and 3 with long-term phenomena, including Climate Change.

2. The Institutional Framework of Beneficiaries

The beneficiaries of the technical work as above are the structures dealing with strategic issues and crisis management, in a suitable combination of national and regional targets. Having account for the fairly vertical arrangement of the decision chain in Egypt, they can be framed into three groups only (Coordination and Crisis Management, Strategic Sectors, Scientific and Technical Support).
i. **Coordination and Emergency Management** – the core of the current protection system includes Entities involved in Policy-making (the IDSC – Information and Decision Support Center), Management of operations and Coordination of response (IDSC and NCCDMRR - National Committee for Crisis Management and Disaster Risk Reduction), Emergency response (General Administration of Civil Protection). At the **Governorate level** the National system is duplicated, as the Governor chairs the Governorate Civil Protection Unit and mostly enacts the indications of IDSC and NCCMDRR. As a general statement it is worth observing that – in the current Egyptian system – prevention issues are typically understated with respect to response, and the system shows ready to receive preparedness inputs above all.

Overall, this «Coordination and Emergency Management» group is beneficiary of works on short-to-mid term risk and vulnerability, referred to in particular by the technical notes on Multiple Risk Management, Ground Instability and Seismicity, and Flood Control. As stated above, however, much of the outputs – including the improved monitoring systems – should be exploited in conjunction with long-term risk issues as those on Climate Changes.

ii. **Strategic Sectors** – include both the Environmental and the Urban Development issues. Environmental issues (including Climate Change) are dealt with and managed by the Ministry of State for the Environmental Affairs through the Egyptian Environmental Affairs Agency. Under the auspices of the National Committee on Climate Change (NCCC), EEAA enacts the Egypt’s Climate Change National Action Plan (ECCNAP) by means of its Climate Change Unit (EEAA-CCU). As it deals with the areal distribution of short-, mid- and long-term vulnerabilities at the national and the local scales, a major strategic role is deserved to the Ministry of Housing and its General Organization for Physical Planning (GOPP), in terms of monitoring, planning and control of a sensitive issue as the Urban Development.

Overall, this «Strategic Sector» group is beneficiary of the works Climate Changes and the long-term term Hazards and Vulnerabilities, in particular those referred to in the technical notes on the Control of Coastal Erosion and Marine Submersion, and the Water Scarcity Management. However, the sector shall also benefit of part of the outputs of Multiple Risk Management and of Ground Instability and Seismicity, in particular, those related to the Integration of Climate Change Adaptation and Mitigation Measures in urban context, and those on Monitoring (more than early warning) Systems.

iii. **Scientific and Technical Support** – A perspective picture of the needs in Scientific and high-level Technical work at the national and supra-national scales, led to add this small group of Entities acting – at the same time – beneficiaries of, and contributors to the activities dealt with in the Action Plan. The group includes four Entities provided with miscellaneous scientific and technical expertise, covering the national territory and carrying out scientific work alongside their technical Institutional duties:

- two independent Authorities: the NAARS - National Authority for Remote Sensing and Space Sciences, and the EMA – Egyptian Meteorological Authority
- one major Research Institute: the NRIAG - National Research Institute of Astronomy and Geophysics with its Egyptian National Seismic Network (ENSN)
- one major Non-Governmental Organization operating at the national-level, the Egyptian Red Crescent.
In consideration of the peculiar scientific problems associated to the understanding and the forecast of the dynamics of northern Egyptian shores – and the inherent impact on the protection of those heavily populated areas – the possibility of a partial involvement of the Coastal Research Institute (Co.R.I) of the National Water Resource Center (NWRC) should be explored.

In addition to its coordination and management role, the IDSC can also have a scientific and technical function through the Center for Future Studies (CFS), which can help in research work concerned with scenario building exercises and other future studies methodologies (e.g. Delphi) that can be useful in drawing plausible future scenarios for 2030, e.g.:

- in the Preventing Sea Submersion Risks action sheet different scenarios of areas that might experience sea submersion by 2030 and the potential effects and costs could be executed by the IDSC as action plan supporting research,

- and CFS can also be useful with respect to Early Warning System, in the research related to the management of flood scenarios.

3. Establishment of a Monitoring and Follow-up Mechanism

The preparedness for natural disasters and climate change adaptation will require a solid mechanism for monitoring changes related to the urban environment and the accumulative effects of sea level rise. This action aims at establishing this mechanism within the national urban observatory (NUO) in order to:

- Monitor and evaluate the effects of the climate change on the urban environment and extrapolate future trends and risks. Those future trends will assist in the accurate and continuous revision of the urban area classification based on its vulnerability to climatic change threats.

- Monitor and evaluate adopted actions and policies and their effect on the adaptation to climate change.

- Establish an early warning system against possible disasters and risks.

- Provide the decision and policy makers with information on urban conditions and trends.

- Coordinate with national and international Observatories and Monitoring and Evaluation (M&E) institutions in order to develop indicators and trends.

The **Egyptian National Urban Observatory** (NUO) is an important coordination tool among all agencies concerned with urban development processes. The NUO is affiliated to the General Organization for Physical Planning (GOPP). Its key mandate is to provide all relevant data and urban indicators to decision and policy makers responsible for preparing and formulating national urban development policies. Local Urban Observatories are now in the process of being established in each governorate. It is proposed that a mechanism for early warning and monitoring climate changes to be incorporated within the **Local Urban Observatory** (L OU) of Alexandria.
The mechanism will include:

- A set of urban and environmental indicators that describes and monitor changes in the urban environment related to climate change effects (e.g. sea level rise, seismic activities, flooding, etc.)
- A monitoring unit to follow-up progress in the implementation of mitigation and adaptation measures.
- An early warning system connected to other LUOs and regional observatories (Regional Arab Urban Observatory and the Global Urban Observatory).
- Provide training and capacity building for local staff involved in the LUO Alexandria.
- Prepare and circulate reports and periodic brochures for public awareness and dissemination of best practices.
- Periodically update and assess the urban vulnerability classifications based on indicators. The updated vulnerability map could add or eliminate zones based on previous trends and current measurements.

**Anticipated constraints and difficulties** are: weak local mechanisms for monitoring and follow-up; monitoring and follow up mechanisms will need the National Government financial support.

**Uncertainties** cover: the ability of the local authority to properly supervise the Monitoring and follow-up mechanism; the availability of trained and permanent staff for implementing climate change adaptation measures within the local urban observatory; the lack of accurate data sources in some urban sectors and uncertainties regarding climate change magnitude of effects.

The **contracting authorities** would be the Alexandria Governorate, the GOPP – National Urban Observatory, and the NARSS – National Authority for Remote Sensing and Space Sciences.

**Costs and scheduling** of this mechanism could be as follows:

- Establishment of Local Urban Observatories by 2012: 1,700,000 EGP
- Incorporating mechanisms for climate change monitoring by 2014: 3,400,000 EGP
- Establishment of an early warning system regionally and nationally connected by 2017: 10,200,000 EGP.
1. Profiling Cash Flows

It is here question of assess and establishing the profile of the two coefficients that characterize the flows evolution: \( \alpha_{CC} \) et \( \alpha_F \). Those two components are clearly distinct but it is important to establish them together in order to ensure that the global flow profile is acceptable. We are here dealing with the subject from the global point of view for the three study sites, in order to maintain some homogeneity. One part of the question deals with the climate change even if it is essentially a key point for the sole Tunisian case.

\( \alpha_{CC} \) is not problematic until 2050; indeed, the climatic previsions are acceptable on the 2030-2050 period, it can be considered as nought on this interval. It is only to facilitate calculation and does not aim to provide with a faithful transcription of what happens from a physical point of view (CC has probably more continuity). What matters in our approach is not much into the capacity of valuing a given flow but rather in aggregating them into compact global indicators such as NPV or B/C (cf. 1.4.4). Between 2010 and 2030 we choose \( \alpha_{CC} \) constant so that in 2030 we can correctly find the imputable part to the CC in the AAC of each disaster\(^{20} \).

It is tempting to take a speed of growth for the 2010-2030 period identical to the 2050-2110 period. Indeed the CC is today understood like a phenomenon with inertia and positive retroaction; by conserving the same rate we can then considerate we are staying consistent with the conservative approach. Yet it is not abstruse either to push conservatism to further limits by taking a growth equal to zero on this interval, contemplating greater uncertainties of the models on the longer term but also the limited validity of global models on a more localized scale.

Let us observe what can occur. With \( u=25\% \), which is representative of the whole disasters considered in Tunis, we would obtain an annual growth of 1.45\%. We can also consider that, just like the uncertainty of the climatic previsions concern the whole 2030-2050 period, the rate, beyond 2050, instead of being based on a 20 years catching up (between 2010 and 2030), we can be based on a 30 to 40 years catching up which respectively corresponds to growth of 0.96\% or 0.72\% (still with \( u=25\% \)). We then obtain the following profiles:

\[ \frac{1}{(1+u)^{n-1}} \]

\(^{20}\) If we call it \( u \), we then have \( \alpha_{CC} = \frac{1}{(1+u)^{n-1}} \).
Let again insist that this curve does not intend to be faithful to any economic translation of a complex physical phenomenon such as CC but is only valid for the calculation that is undertaken under the framework of this study\textsuperscript{21}.

The horizon is here sufficient for the exponential growth sensitivity to unfold. This question requires an even more delicate examination of the growth profile sensitivity in order to be dealt with properly.

The growth profile can be considered as well known until 2030, for which a constant of 4\% appears as reasonable, even if the proximity with the Euro zone that seems in deep stagnation could slow down this growth in the 20 upcoming years (it is not obvious that the sole local or regional consumption could cope with such a high growth in the 20 next years). The 2030-2050 period remains anticipated as favorable for growth, even if on this horizon, the approach is already highly speculative. With a population climax in 2050 and a progressive growth decrease from then on, one can imagine on the longer term, a smaller growth. All this remains insufficient in order to determine precise rates. Likewise, let us imagine a unit flow for 2030 and let us observe its profile according to different hypothesis: a rate triplet (4\%, 3\%, 2\%) on the three periods – in red, a constant rate of 3\% on 100 years (direct application of the A1B scenario) – in green, a triplet (4\%, 2\%, 2\%) in purple, and finally a triplet (4\%, 2\%, 1\%) – in light blue. We make two simulations, whether we take $\alpha_{CC}=0$ or $\alpha_{CC}=0.96\%$ from 2050 on (median assumption):

\textsuperscript{21} It would have been also possible to consider a linear progression until 2050 to smooth the profile. Unsurprisingly that ends up to almost exactly equal overall results.
The constant 3% scenario differs from the others; it finishes with almost half of the other previous scenario’s value (4-3-2). Even the slowest scenario (4-2-1) finishes with values twice inferior to the (4-2-2) scenario that is the one right above. We can also see that the CC impact of the flows in particularly visible beyond 2050. It is **around the 2070-2080 decade that the flow profiling effect is appearing** and the gaps become visibly wider.

On one side, it is not so satisfying because we can sense that from 2050, or even 2070, things generally lack of control. On the other hand, **on 40 or 50 years horizons, the values are more grouped and the confidence in the results rather satisfying.** Yet our adaptive measures concern this type of horizon.

Those uncertainties on the long term could be compensated by the temporal discounting. But nothing is less certain in our case, as we are using decreasing rates from 2030 one. We examined in 1.4.1 links between temporal discounting and growth, and measured their complexity.

But intuitively, making the discounting rate decrease implicitly amounts to suppose a diminution of growth. For instance, if we put ourselves to the initial recommended rate (see 1.4.1: $x=7\%$, globally equivalent to a constant rate of 5.32%), we obtain the following profile:

Between 2030 and 2050, the rate is almost amputated by 225 basis points, and additional 175 bp on the 2050-2110 period. These reductions are in absolute terms closer to the one obtained for the most prudent growth profile (4%, 2%, 1%) that we hence select to keep a fair level of consistency between nominator and denominator.
Let us now take this scenario and examine its discounted evolution over time, and this for all the different initial temporal rates (from 4% to 10%) and including the CC contribution to the appreciation of flows:

Between 2010 and 2030, we notice without surprise that the flows are growing for values of \( x \) inferior to the sum of the growth rate (4%) and the CC impact (1.45%). 2030 is a key year, as the flows are clearly slowed down, on the one hand due to the slowing down of growth and on the other hand due to the CC stabilization. Nevertheless, the slopes on this period are not as excessive as one should expect, in comparison to similar exercises. Another interesting phenomenon is that from a certain horizon (approximately 2060), the flow increases. In itself this doesn’t represent a fundamental issue, even if it is far from being common. It is thus true that the mass repartition profile is particularly surprising for \( x=4\% \) and \( x=5\% \), when the 20 first years barely weight anything in the total. In is then interesting to represent the absolute mass distribution (left graphic) and relative (right graphic) according to the different scenarios:
The accumulation of flows value on 100 years is very variable according to $x$, in a ratio from 1 to 3 approximately. This proposition isn’t really reduced even by dividing the horizon by 2 (around 2050). Nevertheless, around 2030, we are located in a ratio from 1 to 2, but we know that this horizon is too short for our purpose. The right graphic is very instructive. We naturally notice that the curve is more concave as $x$ is high; we also notice some differences in the mass repartition, especially in the first 40 years. Nonetheless, in this period there is some proximity between the curves, which isn’t a negative element. Beyond 2050 or 2060, the gap between the curves sensibly diminished. The importance of those last decades is obvious. It is a concern: the discounting seems too low to diminish the weight of the period of greater uncertainty. In the hypothesis other growth profiles less severe than the (4%, 2%, 1%) triplet, the situation is even more excessive in that regard, and most of the profiles end up not very credible (except for $x$ close to its maximum of 10%).

As mentioned earlier, this incites to put into perspective the impact of the model. To schematize, it seems that the model remains more robust on a shorter horizon, like 50 years. On one century, uncertainties are such that a qualitative sentiment would be preferable. Fortunately, the reduced horizon where this model is valid is most often sufficient in the frame of this study. Indeed, most of structural measures have a 10, 20, 30 to 40 years horizon. The reduction of the horizon globally follows the conservative principle line (see phase 1).

In the case of projects requiring more important horizons, like for example taking into account natural goods and particularly forests, an additional work would probably be necessary.

It is now question of exactly establishing our horizon. After repeated tests on mass repartition curves (like those presented above), we will finally take H=40 years.

This horizon seems appropriated because it corresponds to the cover of all the validity period of the climatic previsions made, using as a center the key year 2030. As mentioned before, this horizon also enables to cover the infrastructures’ life expectancy proposed as adaptive measures. We will only partly count the costs, corresponding to the fraction of the 40 years horizon in comparison to the life cycle of the measure studied. This horizon enables to balance the relative weight of the 20 next years with the 20 following, in order to conciliate the necessity to take into consideration the intergenerational link with the concern of obtaining tangible results in a rather short term. Indeed, in the case that H=100 years, the 20 next years then only have a weight of 25%, what seems not to coincide with the society and decision makers main focus. With H=40 years, the two next decades reach the symbolic barrier of 50% (58.6% for $x=7\%$).

Here are the mass curves on the horizon of 40 years (2010-2050) with $\alpha_F = 4\%$, values chosen for Tunis:
Those curves are satisfying, in the sense that they take into consideration long term benefits without neglecting theoretical or pragmatic justifications (intergenerational balance, growth of flows, temporal logic respected), with uncertainties both acceptable considering the difficulty of the exercise but also because there is no discrepancy between the sensitivity of the variables and the results.

Based on the study of the projected series of local GDP in phase 1, we propose the following adaptation in the respective cases of Morocco and Egypt: $\alpha_F = (4, 8\%, 2, 5\%)$ and $\alpha_F = (3, 5\%, 2, 5\%)$.

Another way of broaching the exercise would have been to integrate the reflection upon growth to the study concerning the sensitivity of the temporal discounting rate. This corresponded to taking a constant flow (or simply adjusted CC-wise) and to choose the $\gamma$ factor in the bottom of the range rather than of the top (see 1.4.1). We preferred a methodological approach of each parameter with a clear distinction between the flows and the temporal discounting. One can admit that the alternative could enable to combine two major uncertainties into one.

In this perspective we can even to a simplification that could be considered as excessive but being concise: we notice that $\beta$ is of the same order as $\alpha_{CC}$; therefore, mentally, they cancel each other. Then the flows growth comes and cuts $\gamma$.

The importance of this factor is once again put forward. If it is big enough (around 2), this comes back to discounting a constant flow to the growth. If it only equals 1, flows remain constant over time. Shall it be necessary, here is an additional demonstration that the attitude to risk remains a fundamental element in any project assessment.

The necessity to dispose of more methodology in order to evaluate in a better way the different parameters, especially $\gamma$, which captures a part of our link to the future, to wealth, to risk, is even reinforced. More globally, the state of the art still doesn’t offer any approved “toolbox” for this type of exercise.
## 2. Detailed Calculations– Discounted Cash Flows of Adaptation Options

### Anti-seismic measures

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## Health – cumulated damages

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Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa Final Version
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