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Technical Adaptation of Mediterranean Cities at Flood Risk in Climate Change Context

Quentin SAVENIER

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This synthesis «**Technical adaptation of mediterranean cities at flood risk in climate change context**» was performed by **Quentin Savenier,** student in the AgroParisTech-ENGREF specialized master "Water Management" (post-master degree) in Montpellier.

TECHNICAL SYNTHESIS

Technical Adaptation of Mediterranean Cities at Flood Risk in Climate Change Context

SAVENIER Quentin
Email:quentin.savenier@agroparistech.fr

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GLOSSARY

CEPRI: Centre Européen de Prévention du Risque d'Inondation
CMI: Center for Mediterranean Integration
DI: Directive Inondation
EPRI: Evaluation Préliminaire des Risques Inondation
GFDRR: Global Facilities for Disaster Reduction and Recovery
IPCC: Intergovernmental Panel on Climate Change
PGRI: Plan de Gestion des Risques d'Inondation
SNGRI: Stratégie Nationale de Gestion des Risques d'Inondation
SLGRI: Stratégie Locale de Gestion des Risques d'Inondation
SUDS: Sustainable Urban Drainage System
TRI: Territoire à Risque important d'Inondation
UNDP: United Nations Development Program
UNEP: United Nations Environment Program
UNFCCC: United Nations Framework Convention on Climate Change
UNISDR: United Nations International Strategy for Disasters Reduction
WB: World Bank
WMO: World Meteorological Organization

ABSTRACT

The consensus on climate change has been established since the fifth report of the Intergovernmental Panel on Climate Change (IPCC). In this situation, this report aims to present an inventory of fixtures for Mediterranean town flood risk management. The design and the implementation of flood adaptation strategies at the local level is a complex task for policy makers, as they have to cope with a high diversity of stakeholders and scenarios. These stakeholders have various perceptions and relationships to natural hazards, and reflect different socio-economic and socio-psychological backgrounds. Moreover the effects of climate change create different unknown forms of risk along with the inherent uncertainty connected to flood risk.
In this context, Mediterranean adaptation strategies are built on the experience of each urban area and climate change scenario. This presents a challenge for both climate and hydrologic modelling to predict the evolution of rainfall and storm water, especially for extreme events in this part of the world.
In order to keep the Mediterranean basin an attractive place for tourism and life quality, and limiting dangerous flooding, adaptation strategies have to deal with urban and economical development of the towns. Projects in several urban areas have implemented new structural measures improving the resilience by careful design. This kind of design can also have a collateral beneficial effect. Projects show the adaptation evolution between North and South of the Mediterranean region. There is also international cooperation which allows making bigger projects and sharing the knowledge. Finally, the report presents an overview of the progress and needs related to Mediterranean flood control in different countries.

Adaptation - Climate change - Flood - Mediterranean towns - Mitigation - Resilience - Structural measures - Urban area.

RESUME TECHNIQUE

Le consensus sur le changement climatique s'affirme encore depuis la parution du 5e Rapport du Groupement International sur l'Evolution du Climat (GIEC). Le présent rapport a pour but de présenter un état des lieux de la gestion du risque inondation des villes méditerranéennes. La conception et la mise en place de stratégies locales d'adaptation aux inondations apparaît complexe pour les autorités publiques, qui doivent faire face à une grande diversité de scénarii et d'acteurs. Des acteurs qui ont des perceptions différentes vis-à-vis des risques naturels, influencées par le contexte socio-historique. Les effets du changement climatique peuvent également engendrer une certaine variabilité des risques combiné à l'incertitude inhérente à l'aléa inondation.
Dans cette situation, les stratégies d'adaptation méditerranéennes s'établissent sur l'expérience historique de la gestion de l'aléa ainsi que sur les données du changement climatique disponibles. Cette étape présente un défi pour les modélisations de scénarii climatiques et hydrologiques afin de prévoir l'évolution des précipitations et des tempêtes, notamment pour les évènements extrêmes.
Dans le but de garder le Bassin Méditerranéen comme un espace touristique où la qualité de vie est attractive, les stratégies d'adaptation aux inondations doivent s'intégrer au développement économique de la région. Certains projets urbains s'intéressent aux techniques alternatives pour améliorer la résilience urbaine, sur les rives Nord et Sud qui peuvent montrer dés bénéfices collatéraux. Une coopération internationale permet alors le lancement de grands projets d'aménagement.
Ce rapport présente ainsi une approche des progrès et besoins techniques dans la gestion du risque inondation en Méditerranée.

Adaptation - Aire Urbaine - Atténuation - Changement climatique - Inondation - Mesures structurelles - Résilience - Villes méditerranéennes.

SUMMARY

LIST OF FIGURES

INTRODUCTION

The idea of "dealing with climate change " (Stocker, 2014) is part of one of the biggest challenges of the 21th century for humanity. The consensus built up around this notion comes from the scientific world's conviction with respect to the committed phenomenon. However, many uncertainties remain about the potential effects of this change, nature and intensity.

As such, strategies of adaptation to the various impacts are gradually organized to pursue the development of human activities. Responsibility of the direction of these strategies belongs to public policy makers, even if local and private initiatives are emerging. These include for decision-makers to establish a framework of measures and facilitate or promote adaptation projects consistent with territorial development.

In this context, flood risk management appears difficult because of the high uncertainty inherent to its nature. This is even more complex given that the projections respond to different climate change scenarios.

Flooding is the natural disaster due to climate having the highest frequency in the world and the Mediterranean. However it remains difficult in the scientific world to establish a real link between the occurrence of this disaster and future climate disruption. Some research centers still trying to move forward in this domain such as Oxford University with the project "climatprediction.net". A increase can however be observed over the period 1980-2011 (see Figure 1) according to United Nations International Strategy for Disaster Reduction (UNISDR).

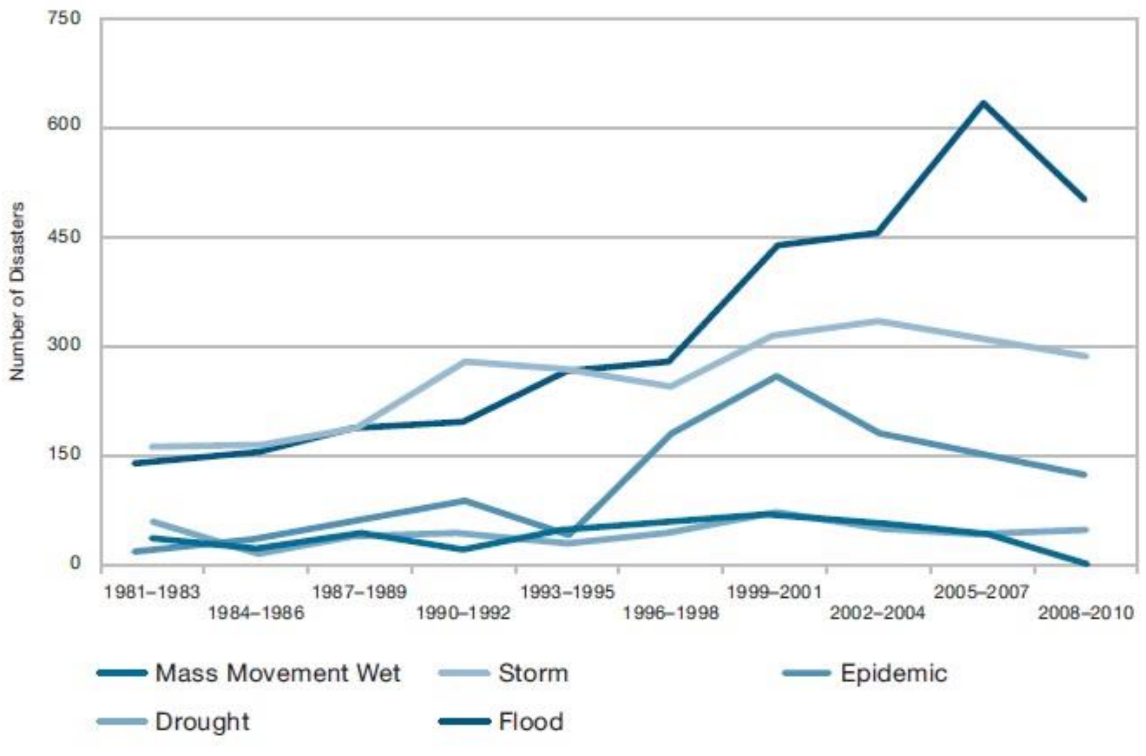


Figure 1 : Trends in water-related disasters. Source: EM-DAT/CRED (2011)

CLIMATE CHANGE AND FLOODING IN THE MEDITERRANEAN

THE MEDITERRANEAN

The Mediterranean region can relate different dimensions (geographical, cultural and climate) that are not clearly linked. To illustrate this fact, the Adelaide region in Australia is subjected to a Mediterranean climate while the Nile Delta is not. A truth that finds itself completely reversed from a purely geographical point of view. We also note that the UfM (Union for the Mediterranean) includes the EU and therefore the northern countries of Europe.
It is then important to indicate that the geographical dimension is put forward in the present report. Topics that are discussed are related to countries bordering the Mediterranean Sea on both northern and southern shores. In a more precise way, and to keep a certain homogeneity within the observed territories, we focus on the Mediterranean coast which is characterized by a link to the sea, a high urban population density and strong tourist attraction that puts the region as world leader in extreme of attendance (Magnan and al ., on 2009). An exception will be made for the western region of Morocco which is bordered by the Atlantic Ocean but is still regarded for its projects of adaptation. The scope is given by the map of Figure 2.

Figure 2 : Mediterranean region

CLIMATE CHANGE

Data and known consequences

Warming of the climate system is unequivocal, and since the 1950s, many observed changes have been unprecedented for decades. The atmosphere and ocean have warmed, sea levels have risen and it has become an undeniable increase of greenhouse gases concentrations in the atmosphere (Stocker, 2014). The Mediterranean basin will appear during the 21th century among the most severely affected areas. By 2100, the area will know, according to different climate models, an increase in the average temperature of 2 to 4°C, a decrease in rainfall of 4 to 30% and a rise in sea level from 18 to 59 cm (Blue Plan for the Mediterranean, 2011). The report of the World Bank "Turn Down the Heat 3" confirms these possible trends.

Concerning flood risks, it is mentioned in reports a high probability to know, in the future, more extreme events with episodes of abundant precipitations more intense and frequent over land-surface of mid- latitudes as the Mediterranean Basin (Stocker, 2014). A trend to more frequent and intense flooding events is planned with a very likely increase in the peak spring flooding due to snowmelt and flooding in coastal areas impacted by sea level rise (Intergovernmental Panel on Climate Change, 2012).

Reaction of human societies

The changing climatic conditions affect the water cycle and thus require revising the management of the resource. Impacts, in addition to those assumed in the risk of flooding, will also affect overall other sectors such as food production and drinking water (Field et al., 2014). It is then essential to work on an integrated management of different sectors concerned, to provide effective and optimized measures.

Beforehand it seems useful to remind the definition of mitigation and adaptation measures developed by the UNFCCC:

- **Mitigation** : is a human intervention to reduce sources or increase the wells of greenhouse gases (Intergovernmental Panel On Climate Change ., on 2014).
- **Adaptation** : is the process of adjustment to the current or expected climate, as well as its consequences. In human systems, it is to mitigate or avoid adverse effects and exploit the benefits (Field et al., 2014).

In this report, only the adaptation process is discussed, although it is possible to consider actions that combine both measures, for example in the development of forest areas that could play a role in minimizing flooding and constitute wells of carbon.

In order to make this effective adaptation, it is essential to identify the issues on the territory that is to be protected. The urban areas appear at the head of the threatened zones. Thus, it is mentioned in the SUEMS (Sustainable Urban Euro-Mediterranean Strategy) of the UfM (Union for the Mediterranean) that "the catastrophic floods [...] are a major risk for many Mediterranean cities in Algeria, Spain France, Greece, Italy and Turkey. Among the most vulnerable Mediterranean areas are the coastal areas, whether north or south of the basin as well as areas of high population growth (southern and eastern) where are dense cities and suburbs."[1].

FLOODS

Event characterization

The floods are characterized by an exceptional water supply in an area during a short time without having time to be regulated naturally or artificially (infiltration, runoff, storage).
It is important to remember that this hazard is generally the result of the combination of meteorological and hydrological extremes.
It can also be the result of human activities, where the growth and development of these are made on naturally settled and flood plains, or upon failure of artificial structures such as the breaking of a dam. The different type of floods and their causes are shown in Table 1 below.

[1] From the working group PNUE/PAM/blue plan : *Sustainable Urban Euro-Mediterranean Strategy (SUEMS) within the framework of the Union for the Mediterranean - A diagnosis of Mediterranean cities situation (2012)*

Table 1 : Types and causes of floods (source: World Bank 2012-*Cities and flooding*)

Types of flooding	Causes naturally occuring	Human induced	Onset time	duration
Urban flood	River Sea Rain Groundwater Flashflood	Saturation of drainage and sewage capacity Lack of permeability due to increased concretization Faulty drainage system and lack of management	Varies depending on the cause	From few hours to days
Rain and overland flood	Convective thunderstorms, severe rainfall, breakage of ice jam, glacial lake burst, earthquakes resulting in landslides	Land used changes, urbanization. Increase in surface runoff	Varies	Varies depending upon prior conditions
Coastal (Tsunami, storm surge)	Earthquakes Submarine volcanic eruptions Subsidence, Coastal erosion	Development of coastal zones Destruction of coastal natural flora (e.g., mangrove)	Varies but usually fairly rapid	Usually a short time however sometimes takes a long time to recede
Groundwater	High water table level combined with heavy rainfall Embedded effect	Development in low-lying areas; interference with natural aquifers	Usually slow	Longer duration
Flash flood	Can be caused by river, pluvial or coastal systems; convective thunderstorms; GLOFs	Catastrophic failure of water retaining structures Inadequate drainage infrastructure	Rapid	Usually short often just a few hours
Semi-permanent flooding	Sea level rise, land subsidence	Drainage overload, failure of systems, inappropriate urban development, Poor groundwater management	Usually slow	Long duration or permanent

The flooding in urban areas can take several forms. Identifying the causes of the event and the possible management of different impacts is important in determining an adaptation strategy (Jha et al., 2012). To optimize the latter, a transversal approach of various impacts and possible conversion in positive effects of these allow to implement multifunctional , sustainable and high potential measures, sometimes called "no regrets" (Plan bleu pour la Meìditerraneìe, 2011).

Concept of risk

Flooding is also associated with the concept of risk which is the combined effect of a vulnerabilty of a territory and of a hazard or phenomenon (Brémond, 2011). Studies on climate change show that the distribution of weather events will evolve and also the frequency of extreme events : " An extreme event in the current climate may become more common or rare under future climate conditions"[2].
The Figure 3 below is used to represent the phenomenon of change in the statistical distribution of rainfall induced by changing climatic parameters.

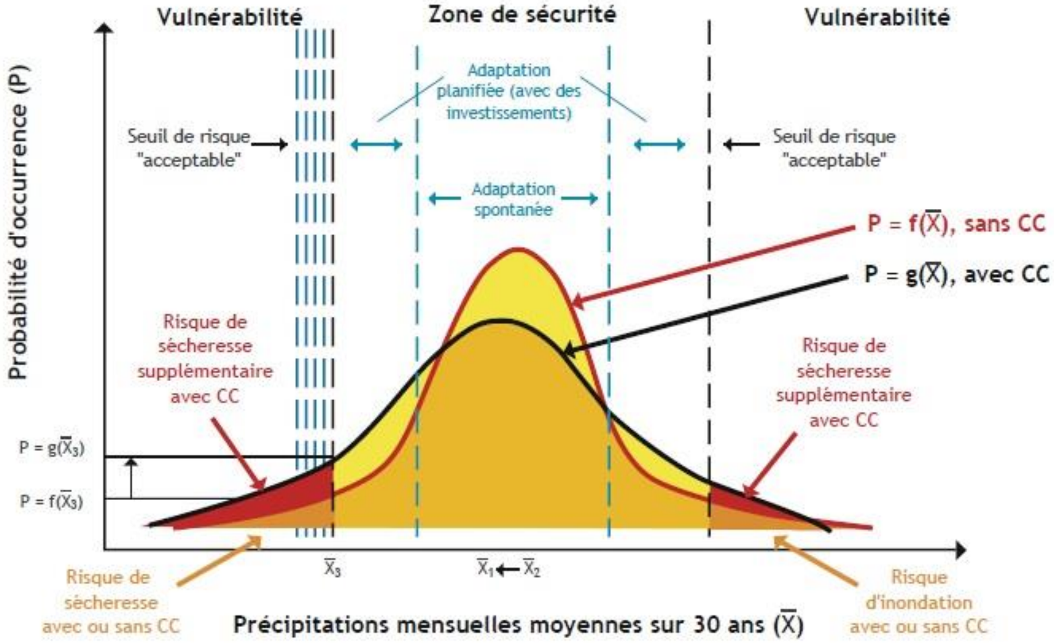


Figure 3: Evolution of the statistical distribution of precipitation (blue plan 2011, Stéphane Simonet)

Beyond the likely increase of flood hazards in climate change, which remains difficult to predict , the risk can also become bigger by increasing the vulnerability linked to population growth and development of activities (Poulard et al., 2013). Indeed, demographic forecasts of the Mediterranean basin indicate a strong growth of the population, especially in urban coastal areas.
These forecasts predict an annual average of growth rate of 1.7% for the countries bordering the Mediterranean, leading the population to double in the next 30 years (The World Bank, 2014). This population also has a very strong tendency to settle on the coast, with a concentration 2.6 times higher than the national average . This results in a concentration of activities which sometimes added to the influx of tourists , which may increase urban density by 50% during the summer (Magnan et al., 2009).

But the southern Mediterranean south shore is already being severely affected by flood events (Appendix 1 : Natural disasters in North Africa and Middle East). On an observation period of 30 years (1981-2011), this type of disaster is the most recurrent, with over 300 registered events (representing 53% of the total number of disasters) (The World Bank, 2014). The North

[2] Managing the risks of extreme events and disasters to advance climate change adaption - IPCC (2012)

Shore is no exception, as seen by the events of 2014 (Southern France and Italy during autumn 2014 and Balkans during spring 2014).

In urban areas the risk is more serious, because of the people and property higher causing high vulnerability. This is particularly striking in the industrial areas that can become a source of pollution and cause a subsequent catastrophe.

Particularly high risk can also be identified in the urban areas of high poverty, especially in countries of the southern Mediterranean, where it is sometimes difficult to characterize and where communication has to be specific.

EXISTING ADAPTATION MEASURES

Adaptation measures can show different nature and be appllied to different scales (Appendix 2: Protective measures against flood at the different city's scales). From a global vision and upstream of the agglomeration until the approach of individual housing, protective measures are numerous (rehabilitation of wetland upstream, urban drainage channels, individual rain water collectors , etc. ...) and must be appropriate to the level of action.

POLICY MEASURES

The policy measures aim to fit the conditions of flood risk management. Public authorities also play a key role in supporting actors and their adaptation efforts, by creating or strengthening legal frameworks and technical, economic and financial resources to enable or encourage the implementation of strategy adaptation (Magnan et al., 2009).

On the north shore of the Mediterranean, the member countries of the EU have to implement the Flood Directive 2007/60 / EC (FD) the European Parliament and of the Council of 23rd October 2007. It is still under development in the countries concerned. A Primary Evaluation of Flood Risk (PEFR) was established in December 2011, followed by vulnerability maps (TRF: Territories at Risk of Flooding) in December 2013. Then the Flood Risk Management Plans (FRMP) must be made by the end of 2015. Finally, Local Flood Risk Management Strategies (LFMS) will be set up by the end of 2016. All of these should be in line with the National Strategy for Management Flood Risks (NSMFR) published in 2014. A renewal of each stage is planned every 6 years, and a second cycle will begin in 2018

In order to implement sustainable measures, it was asked to make sure to consider climate change in the implementation of the Flood Directive by member states (ONERC, 2009). In this context, MEPs (Members of European Parliament) decided that the Directive refers to climate change and take into account in the preliminary assessments as well as in the report that the European Commission will establish in 2018.(http://www.pouvoirs-locaux-francais.eu/documents/?doc_n_id=449&arb_n_id=37).

In parallel, the NAPCC (National Adaptation Plan to Climate Change) prepared by the MEDD in France in 2011, recommends the consideration of potential impacts of it on the flood risk in the planning documents (Centre Européen de Prévision du Risque d'Inondation, 2013).

On the southern shore, an international strategy was also implemented in 2012, with the ISDRRM (Islamic Strategy for Disaster Risk Reduction Management) carried out by the ministries of 57 Islamic countries, and a work plan to build regional resilience to Disasters (The World Bank, 2014). This strategy ISDDRM aims to :

– strengthen risk reduction capacity in Islamic countries,

– improve understanding of the risks and access to information,

– promote the financial and insurance-strategies,

– help countries prepare for disasters and strengthen capacity for recovery and post-disaster response.

It is also interesting to note that most countries are implementing adaptation strategies (see Table 2), who have a role in the establishment of development and urban plans and thus influence the resilience of a territory. These reports must be in line with the regulatory documents relating specifically to the risk of flooding.

Table 2 : Exemples de stratégies nationales mise en place dans 9 pays méditerranéens

Countries	Stratégie pour le Changement climatique	Stratégie pour la gestion du risque d'inondation
France	PNACC (Plan National d'Adaptation au Changement Climatique)	SNGRI (Stratégie nationale de Gestion du Risque Inondation)
Italy	SNACC (Strategia Nazionale di Adattamento ai Cambiamenti Climatic)	RBP (River Bassins Plans)
Spain	PNACC (Plan Nacional de Adaptación al Cambio Climático)	PNSCI (Programa Nacional de Seguro Contra Inundaciones)
Greece	NASCC (National Adaptation Strategy of Climate Change)	RBP (River Bassins Plans)
Turkey	RTCCS (Republic of Turkey Climate Change Strategy)	-
Algeria	PANCC (Plan d'Action National des Changements Climatiques)	Stratégie Nationale de Protection contre les Inondations prévue pour 2015.
Tunisia	SNCC (Stratégie Nationale sur le Changement Climatique) avec la GIZ (coopération allemande)	PNCI (Plan National Contre les Inondations)
Morocco	PNRC (Plan National contre le Réchauffement Climatique)	PNPI (Plan National de Protection contre les Inondations)
Egypt	ENSACCDRR (Egypt's National Strategy for Adaptation to Climate Change and Disaster Risk Reduction)	ENSACCDRR (Egypt's National Strategy for Adaptation to Climate Change and Disaster Risk Reduction)

It is important to remember that all the countries bordering the southern Mediterranean are signatories to the UNFCCC (Observatoire du Sahara et du Sahel, 2007).

FINANCIAL MEASURES

To the impacts and damage from flood events, some financial levers exist and can be integrated into national strategies. For the implementation of these financial measures, it is necessary to evaluate the risks and potential losses of each territory. This assessment allows the identification of areas where:

- losses can be accepted without compensation (such as saline intrusion in coastal aquifers by sea elevation) because the cost of adaptation is too large and no lasting effect,

- losses can be shared between the various stakeholders in disaster (national solidarity or insurance system) if the cost of reconstruction is more advantageous than prevention,

- investment on prevention and protection are feasible, effective and sustainable to limit the effects of climate change and flooding.

In the water sector, various economic and financial tools exist for adaptation, the main ones are (Agrawala et al., 2008):

- international and national aid or programs and public funding such as the Adaptation Fund and Global Environment Facility (GEF) for countries in eastern and southern Mediterranean , and European and national funds for the North shore,

- devices based on a price signal, such as water pricing (possible tax for rainwater),

- pooling and risk sharing systems, such as insurance against hydro-meteorological hazards (droughts, floods , etc.),

- private investment including through public-private partnerships (PPP).

Furthermore, by assigning a price of the risk, the development of insurance and/or tariff device (taxes) may also help to make it more real and encouraging the adoption of preventive behaviors (Jha et al., 2012).

Generally, financial tools developed in the context of climate change need to be flexible and adaptable.

TECHNICAL MEASURES

The technical measures in the management of extreme events mainly stem from the policy framework and financial measures made available to stakeholders. In the flood risk management sector, two major technical tool groups differ : the forecasting/prevention tools and structural protection tools.

Non-structural forecasting/prevention measures

Forecast measures mark a willingness to provide information on trends (most accurate and longer-term possible) through models. For this purpose , for example , the project Explore 2070 was conducted in 2012 in France to assess the impacts of long-term climate change on water resources. The purpose of this tool is to produce data and information related to future extreme events, difficult to characterize, to become a tool in the decision process. However, modelling remains a complex approach, asking for a significant amount of data for its creation, and a good knowledge of the degree of influence of each input parameter (Provitolo, 2008). In addition, it requires a good instrumentation of the area concerned to validate the modelled data, knowing that a continuous improvement of benchmark data increases the robustness of the tool. A too low existing instrumentation nowadays on the southern shore of the Mediterranean (Banque Mondiale et CMI, 2011).

Prevention measures are being developed to limit the effect of bad data? when it appeared on the basis of early risk communication. For that WMO (World Meteorological Organization) helps improve observation tools of vigilance and alert especially in the South and East of the Mediterranean (Plan bleu pour la Meìditerraneìe, 2011).

An effective network allows converting an observation information into a vigilance information or alert, thanks to the experience on this information and modelling in the short term, and therefore relatively reliable. This is the case of the French meteorological network, which, in relation to the SPC (Service de Prévision des crues) allows to provide the public an alert to the flood event via the information tool " Vigicrues ". This system is also exists in other countries in the Mediterranean basin, but especially in North Shore. However, a country such as Turkey has implemented a similar initiative called FFEW (Flood Forecasting and Early Warning System) under the leadership of TMS (Turkish Meteorological Services) in partnership with the USTDA (US Trade and Development Agency).

Europe is investing in these tools, as evidenced by many recently launched programs such as "Imprints", "WeSenseIt" and " UrbanFlood" (Commission Européenne, 2014) especially for flash floods in urban areas. More generally, the network IFNeT (The International Flood Network) was established to facilitate international cooperation in flood management and provide warning information (Jha et al., 2012).

In the coastal context such as on the Mediterranean shoreline, early warning systems allow cities to reduce potential losses from storms, surges and tsunamis. A system of "smart buoys" as that proposed for Alexandria, Egypt (Banque Mondiale et CMI, 2011), could create a real-time monitoring. In order to optimize and speed up communication during floods, the development of new warning tools through Internet and social networks can be a new perspective.

Satellite observation is also required to be widely used and make a long-term monitoring of sea level rise and the subsidence phenomena (Banque Mondiale et CMI, 2011) on coastal towns (usually due to intensive exploitation of subsoil resources like groundwater).

"Hard" structural measures

Are named as "hard" structural measures in flood management, fixed human infrastructure and dedicated to the protection of people and property during flooding events.

Depending on their nature, these different types of infrastructure can:

limit the intake of water in advance of fluvial flood risks (dam upriver from the target area),

divert the water flows existing close to human activities (channels, rivers recalibration) for the pluvial and fluvial flood risks,

increase protection along rivers (dikes, buildings enhancement) for the fluvial and pluvial flood risks, increase urban protection storage (retention basin, drainage systems) for the pluvial and flash flood risks,

increase protection in coastal zones (dikes, physical facilities for breaking waves)

Structural measures mentioned above allow significant flood risks reduction. However, such measures must always be properly understood and impact analysis should be performed. Indeed, many unwanted effects or disadvantages such as environmental degradation (Guerrieri, 2002), relocation (or deformation) of the event to other populations (Poulard et al., 2013), and the non-flexibility measures, may appear in contradiction with the sustainable development principle. Thus each infrastructure being sized relative to an event of fixed intensity, it may be ineffective or even aggravating, for a more extreme event. In addition, they are single purpose measures, which may, where inappropriate, represent a significant investment for a small benefit.

At the level of an urban area, the development plan of the city has a very important place in flood risk management. The land, mainly marked by soil sealing, must adapt to the risks prioritizing areas for protection. Progressive permeabilization of urban areas can also be set up and be encouraged as is done in the Rhone-Mediterranean and Corsica Basin (http://www.eaurmc.fr/climat.html). For coastal cities experiencing the effects of subsidence, coastal erosion and / or saline intrusion, migration of infrastructure to the land should be preferred for long-term expansion plans.

Alternative structural measures

The concept of "alternative structural measures" is new in the management of storm water and flood risk . It was established in the 90s (Chocat, 1997) and began to be developed in the early 21st century to see a significant growth today. The aim is to divert the primary principle of structural measures such as single point protection system benefiting a real integrated management to the territory with a multifunctional role(MAIGNE, 2006).

The will that emerges from these alternative techniques is to make a rainwater manager from the source, or "regards to the plot" and make the city more "permeable" to avoid the only drainage. Thus they can temporarily store stormwater volumes, reuse or infiltrate it when not polluted, or treat it passively as close to their drop point when containing pollutants (around of roads, factory platform). Among many possible methods, some are presented here :

Storing roofs (Figure 4) consist in the establishment of a temporary retention pound on the building roof, bounded by periphery blocks. The entire roof deck is made in porous materials to allow maximum storage space without flooding the surface of the structure. The roof can also have plants to increase retention. The water intercepted by storing roofs are not considered as polluted, they can be moved towards a larger tank for reuse (Conseil Regional Rhône-Alpes, 2006).

Figure 4: Example of planted storing roofs (source: artech-étanchéité.com and ecocopro.com)

UltraLight Alveolar Structures (ULAS) are cubic form products recently used for the establishment of civil engineering works (Figure 5). These structures may have a void average higher than 90% which gives them a power storing indisputable. The structural component materials are resistant and thus allow the use of surface land (roads, carparks) . Depending on the nature of the projects and soils, the influence of these works is variable and their final function which can be a simple infiltration or retention/regulation flow to drain to the sewage network (L'eau magazine, 2014). In a project where the structure is used for the recovery of uncontaminated rainwater, this reserve can be used for public watering (http://structures-alveolaires-saul.fr/).

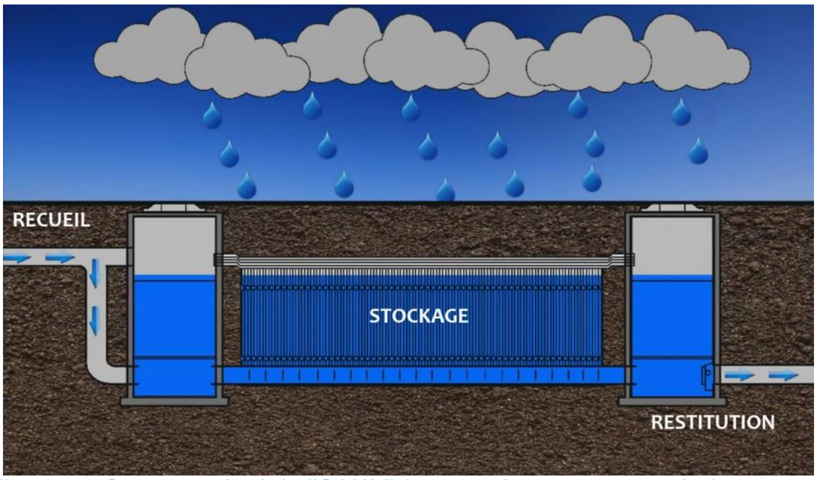


Figure 5 : Storage principle "SAUL" (source: hamon-watersolutions.com)

The swales are wide ditches, shallow, with a profile width and gently sloping edges. Ditches and valleys are two systems for slowing the discharge of the water, with a flow and a water storage in the open air. The water collected in line with these spaces is evacuated by infiltration and/or regulated towards an outlet (wells, basin, collecting network).

using the same principle , the structures of retention/infiltration basins (Figure 6) perform substantially the same function , except that they represent only the devices for the collection and transport (Conseil Regional Rhône-Alpes, 2006). These structures are adapting well in urban areas by simply integrating pre-existing spaces (public parks, sports fields, vegetated ditch in road edge).

Figure 6 : Sports field sized for rainwater storage (source: Cerema)

Pervious pavement are part of " reservoir structures." they are used to permeabilize the roads/carparks (Figure 7) and use the underlying fill area as the unit of storage and drainage (Castro-Fresno, et al., 2013). These structures are made of porous material in order to limit the surface runoff.

Figure 7 : Pervious pavement (source: CAUE de l'Oise)

The strengths of most of these measures are to taking no more land space (important in dense urban areas) and having added utility from the only the flood risk decreasing (groundwater recharge, storage for water scarcity, to refresh heat island, recreational area).

However, the main drawback is the maintenance of these devices which could be relatively important. In addition, a change in the overall stormwater management of a city through a collective network to a single processing wastewater plant, headed for a more localized management to the "source" implies a multiplication of treatment points and releases.

It is still expensive measures more available in the North but the development of these in the South will be interesting to follow (especially when the excess water can be reused).

OVERVIEW : WHAT MANAGEMENT AROUND THE MEDITERRANEAN SEA

GENERAL AWARENESS

Because of better communication on climate change (Field et al., 2014) and the increasingly disastrous experience of floods (and droughts) in the Mediterranean basin, mobilization of the riparian countries is observed.

In the technical field, real development occurs primarily at the prevention and prediction tools, and less explicitly for alternative techniques and syn-event management protection measures (at the flood-time).

For example, a protection strategy against flood risk is scheduled in Algeria for September 2015 as part of a cooperation with the EU and in partnership with a group of experts based in Spain and the Netherlands. At the same time, an early warning system of the population is planned for late 2015, the study was carried out by a Serbian company (Reporters, 2014).

In other countries of the Mediterranean southern shore, a willingness to characterize the vulnerability of coastal cities was felt to better understand extreme events. So it is useful to point out diagnostic studies in Tunisia, Morocco and Egypt to implement adaptation strategies with proposed guidelines for coastal cities of Tunis, Casablanca and Alexandria. These studies are being carried out through cooperation between States, the World Bank and the CMI in association with Egis - BRGM - IAU group (Banque Mondiale et CMI, 2011).

Spring floods in 2014 in South Eastern Europe have led to the establishment of a multi-hazard and transboundary early warning system in the Western Balkans and Turkey to increase resilience to flooding.
Then, the project "Building Resilience to Disasters in Western Balkans and Turkey " was co-funded by the European Commission and implemented by the UNISDR and WMO. It brought together various local, national and regional authorities as well as scientists and stakeholders in the private sector.
Moreover, in the recipient countries, the Expert Exchange Program gave the possibility to create and enhance a disaster risk management network which greatly facilitated the exchange of information between affected countries and providing assistance through bilateral, European and international level (OMM, 2014).

In addition to technical initiatives to improve the data collection, the actions of alternative technical protection measures are also carried out as is demonstrated by the "Workshop for the development of a catalog of good practices in stormwater management" in Morocco with the AGIRE programme (Appui à la Gestion Intégrée des Ressources en Eau). This program has been conducted since 2008 with the support of GIZ (German International Cooperation Agency) for three Moroccan hydrological basins.

Finally, many projects in cooperation with the EU through the LIFE programme (funding instrument for the environment) supports the instrumentation and data collection to promote flood forecasting.(http://ec.europa.eu/environment/life/project/Projects/index.cfm)

SOME PILOT PROJECTS AT THE LOCAL LEVEL

Some urban areas incorporate sustainable stormwater management strategies in urban development projects, including northern shore of the Mediterranean.

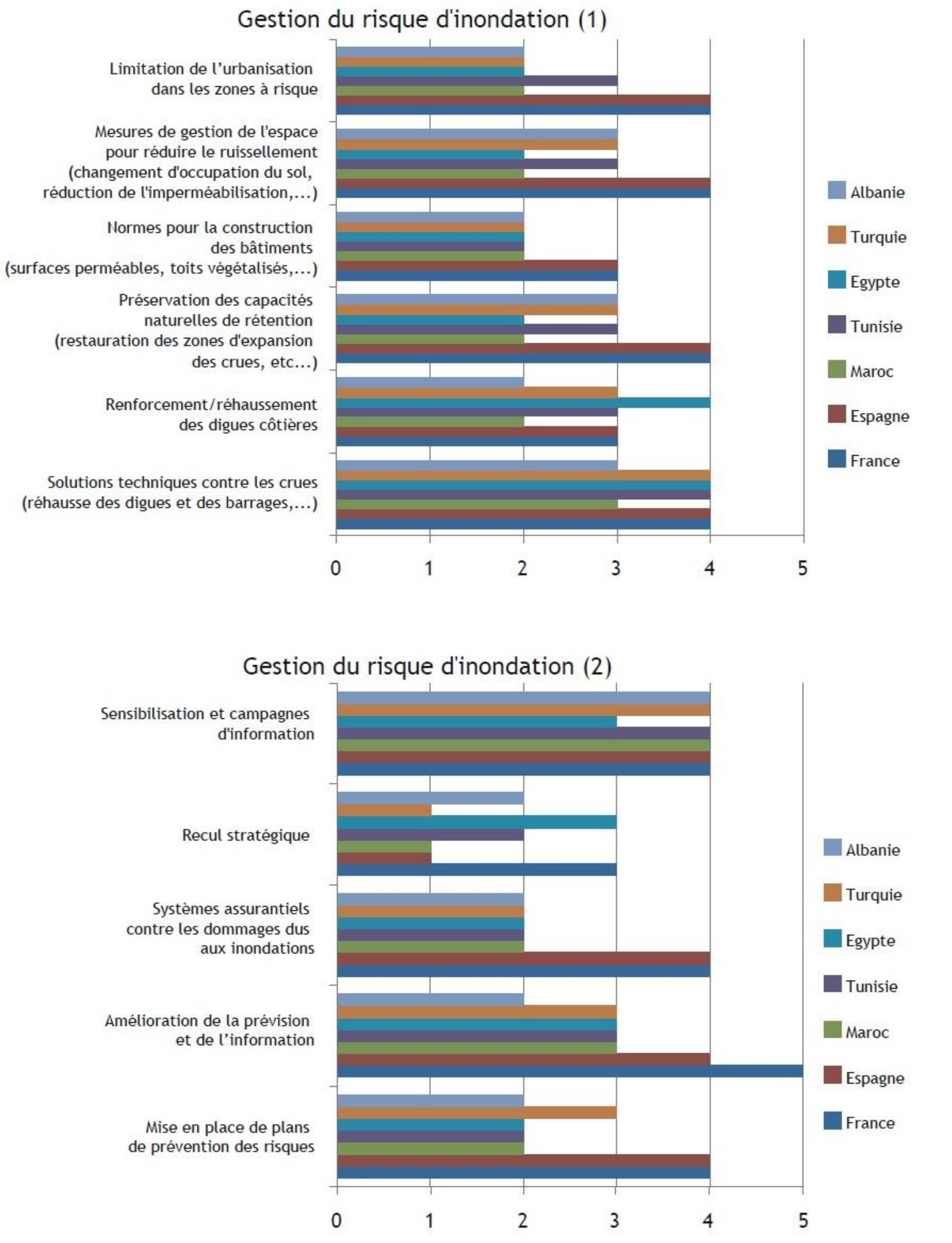
This is the case of Aquaval project (EU LIFE) in the region of Valencia (Spain), which promotes the SUDS (Sustainable Urban Drainage Systems) in addition to the existing water infrastructure through two demonstrative sites in the cities of Xativa and Benaguasil.
The project has many objectives, such as the reduction of the network overflow, re-use of rainwater, reducing island heat effects and flexibility of drainage infrastructure in the context of climate change. For this, the project implements many alternative techniques (infiltration basins, porous pavements, rainwater collection and treatment structures and green roofs).

Beyond, the Aquaval project highlights the importance of involving public administrations in the diffusion of technologies and sustainable strategies for stormwater management of SUDS (as beneficiaries and co-financiers of the project). This commitment helps to stimulate a more sustainable management of city rainwater, in ensuring that rainwater is considered in water resources and territorial planning policies. (Perales and-Momparler al., 2013)

Another example is the urban planning of Montpellier (France) with alternative technical solutions presented at the technical conference "stormwater management" of the RM and C Water Agency (MARTI, 2014). Structures have been built in line with urban planning, including Malbosc area, with swales, landscaped ponds, reservoir pervious pavement and storing roofs.

ADAPTATION STRATEGY: NEEDS AND NOTABLE PROGRESS

At a time (November 2014) when the IPCC present new results on climate change (Stocker, 2014), adaptation (Field et al., 2014) and mitigation axes (Intergovernmental Panel On Climate Change., 2014), national institutions (Protection Strategies) and international (Flood Directive in the EU) work for the implementation of measures to reduce impacts and improve the resilience of territories. Figure 8 shows the status of various measures being established in 7 representative countries of the Mediterranean basin. Some North-South disparity is easily observable, and low progress in the normalization of alternative techniques and controlled urban development (strategic planning retreat).



(1 : Inexistant et non envisagé ; 2 : envisagé mais pas encore en place ; 3 : en cours d'élaboration et/ou mise en œuvre encore limitée, 4 : en place et mise en œuvre avancée ; 5 : en place et mise en œuvre très avancée)

Figure 8 : Implementation steps of adaptation measures for flood risk management in 7 Mediterranean countries (source: Plan bleu 2011)

CONCLUSION

Adaptation to the flood phenomena in a climate change context is revealed as being an important challenge for cities of the Mediterranean. This cannot be achieved easily "no regrets" without a desire to link the development of the urban environment, risk management and integrated water resources management. Many skills exist and keep improving in order to provide opportunities for different actors in this management. However, effort is still needed to acquire relevant data, especially in the South, and the development of decision making support tools to establish a framework of optimal policies and create a consensus that can facilitate the emergence of projects.
Control strategies against flood risks are set up all around the Mediterranean and aim to incorporate the effects of climate change shortly (ONERC, 2009) in Europe. Locally, flood events management is already taken into account in some cities that include alternative techniques in their urbanization project.

Particular attention should be paid to the precarious peri-urban areas of Southern Mediterranean cities, whose inhabitants are the first victims of the floods.

It is also important to remember that the Mediterranean is a culturally rich and diverse region. international cooperation projects are real catalysts through which there is the sharing of knowledge, experience and the financial assistance.

However, even if alternative structural measures will undoubtedly be part of urban development in the 21st century, a good preliminary diagnosis of the risks of the territory will determine the best levers. Thus, we should not "only focus on adaptation technical solutions: depending on the case, some institutional or financial instruments may be more appropriate (eg insurance or flood warning systems rather than heavy protections against floods) and holders of much less inertia and irreversibility."(Plan bleu pour la Meìditerraneìe., 2011)

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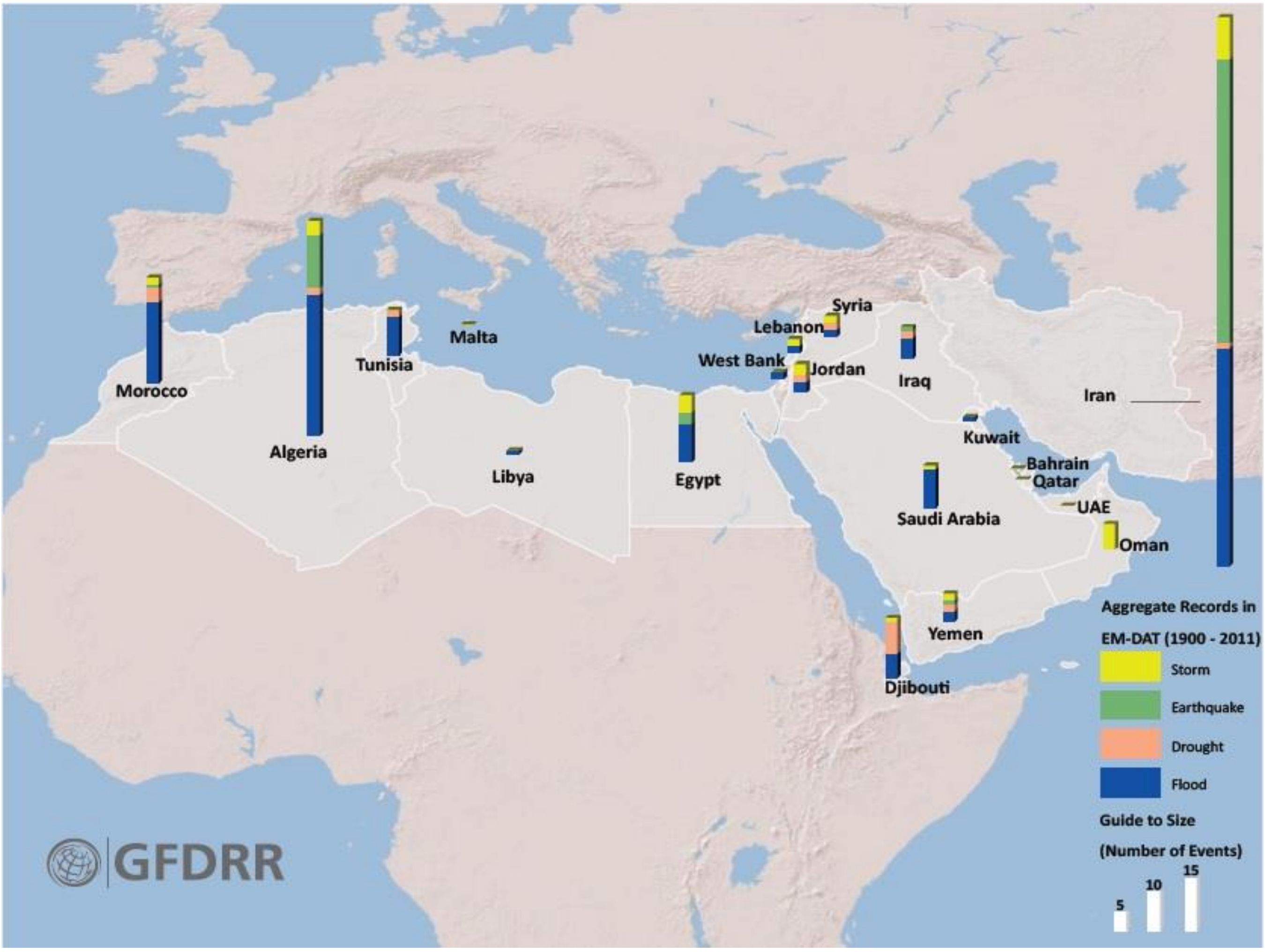
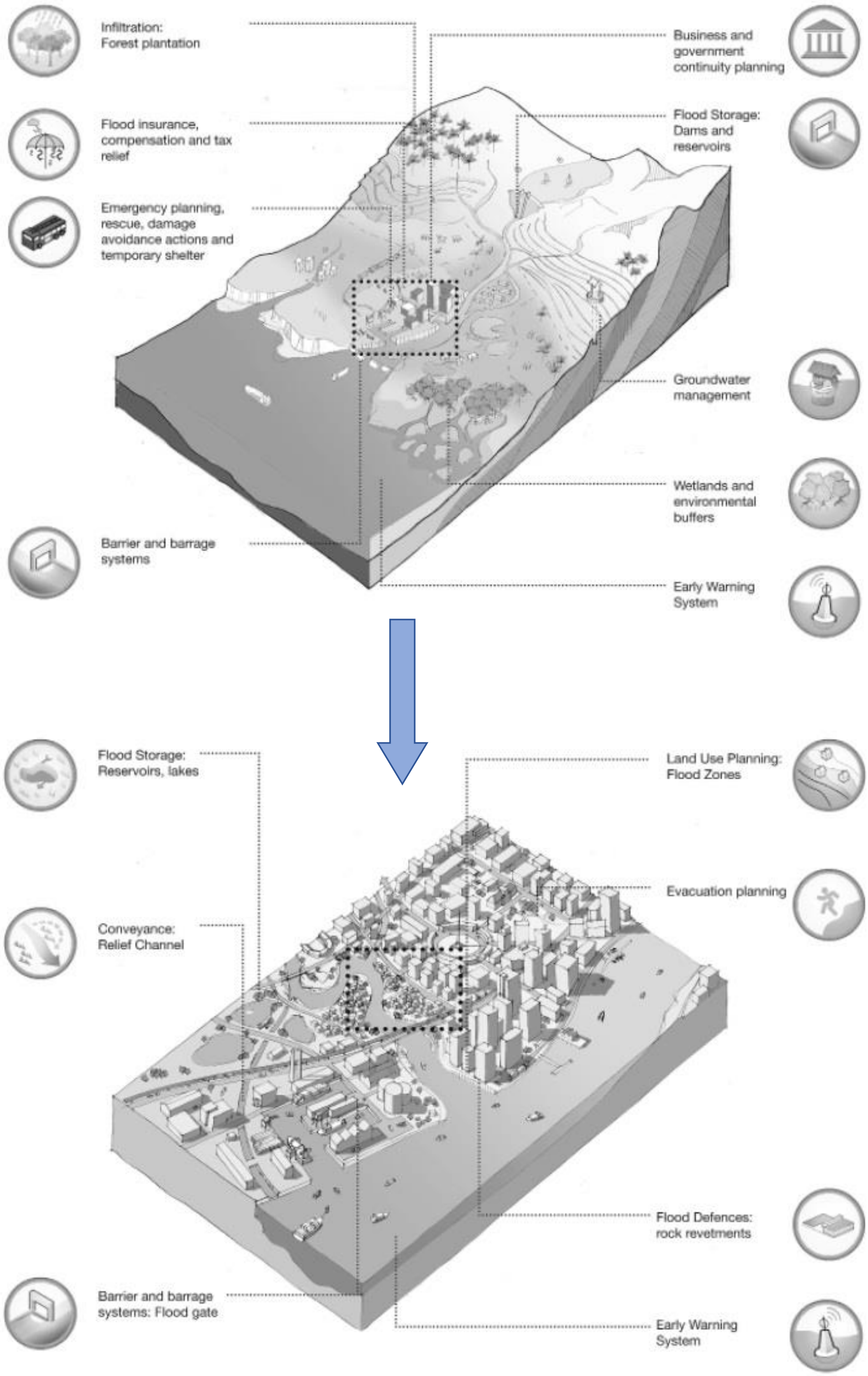
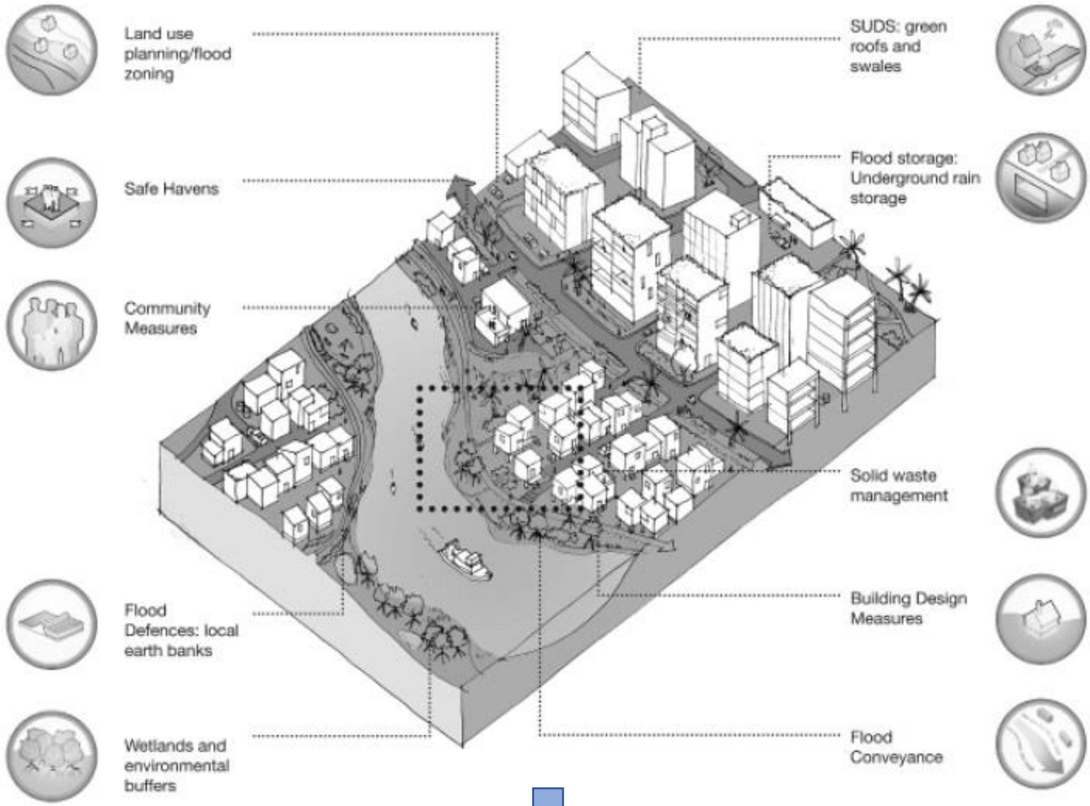
APPENDICES

APPENDIX 1 : NATURAL DISASTERS IN NORTH AFRICA AND MIDDLE EAST

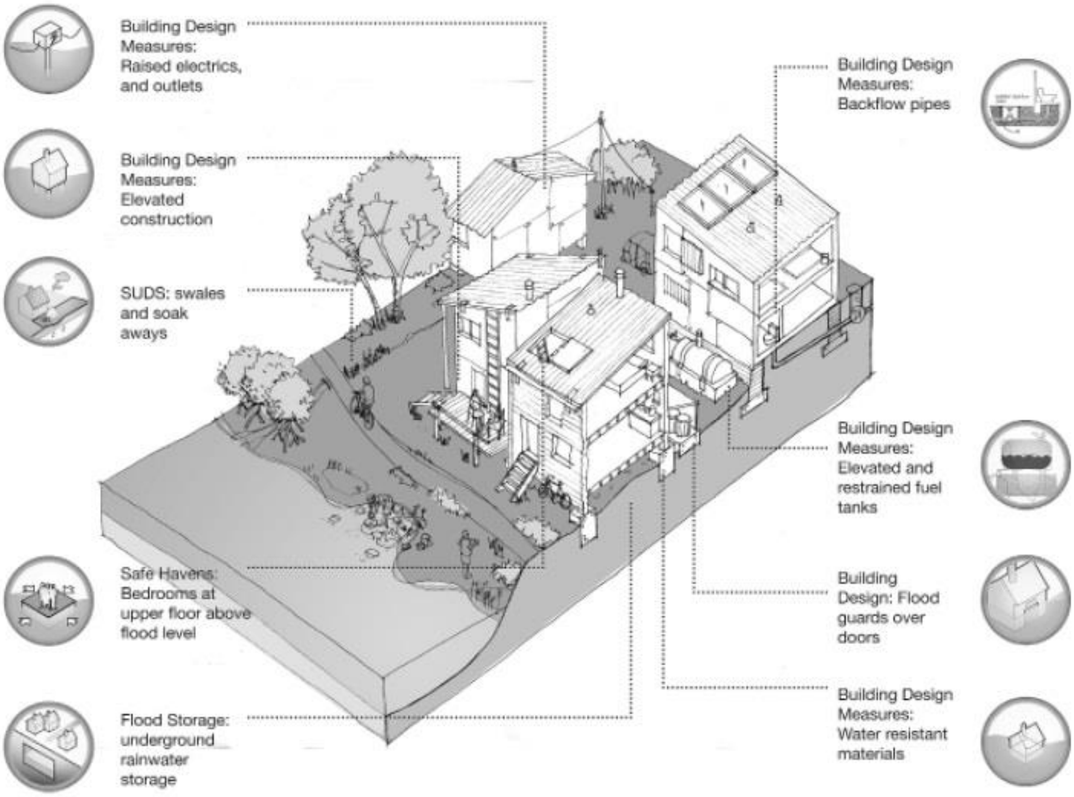


APPENDIX 2: PROTECTIVE MEASURES AGAINST FLOOD AT THE DIFFERENT CITY'S SCALES





Land use planning/flood zoning
Safe Havens
Community Measures
Flood Defences: local earth banks
Wetlands and environmental buffers
SUDS: green roofs and swales
Flood storage: Underground rain storage
Solid waste management
Building Design Measures
Flood Conveyance



Building Design Measures: Raised electrics, and outlets
Building Design Measures: Elevated construction
SUDS: swales and soak aways
Safe Havens: Bedrooms at upper floor above flood level
Flood Storage: underground rainwater storage
Building Design Measures: Backflow pipes
Building Design Measures: Elevated and restrained fuel tanks
Building Design: Flood guards over doors
Building Design Measures: Water resistant materials

648 rue Jean-François Breton – BP 44494
34093 MONPELLIER CEDEX 5

Tél. : (33) 4 67 04 71 00
Fax. : (33) 4 67 04 71 01
www.agroparistech.fr

Office International de l'Eau

15 rue Edouard Chamberland
87065 Limoges Cedex

Tél. (33) 5 55 11 47 80
Fax. (33) 5 55 11 47 48
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