

# METHODOLOGY FOR MATURITY OF FLOOD RISK MANAGEMENT FRAMEWORKS ASSESMENT – APPLICATION TO ASIAN AND EUROPEAN CITIES

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## ABSTRACT

*Urban flooding processes have a significant impact on urban systems and urban communities. Floods are qualified as one of the most frequent hazard, especially in Asia. The population exposed to floods is doubled in the past decade. An economic impact caused by floods has a notable influence on national GDP. The priority of new strategies within flood risk management focuses on reduction of flood impact, short the recovery time and capacity building of human resources. Existing flood risk management frameworks in Asian and European countries are developed based on different principles and focusing on different goals. Research presented in this paper investigates flood risk management frameworks in the case study areas and evaluates their maturity level based on three key elements of flood risk: flood hazard, vulnerability and exposure. Considering the diversity of different frameworks the unique methodology is developed in order to evaluate on both Asian and European flood risk management frameworks. The concept of readiness and maturity associated with a specific grading scale is used. The research is done within CORFU project, an interdisciplinary international project founded by the European Union under the 7 research framework – FP7 – that looks at advanced and new strategies to provide adequate measures for improved flood management in Europe and Asian case studies.*

## KEYWORDS

Flood risk management; maturity; urban flooding; resilience.

## 1. INTRODUCTION

Flooding is characterised as risk related phenomena. It is influenced by natural conditions but also with human activities and undeveloped disaster culture. The urban areas nowadays are facing new flood risks. The extended urban space creates bigger exposure and new forms of flood damages. The urbanization in the last decades has significantly changed the urban environment. Driven by a sense of fully protection, the urban communities have low flood awareness. Today, urban flooding is not just a natural phenomenon, social conditions play an important role.

The development of urban spaces over time has changed. In an historical perspective, the most present development mode of settlements was near the water. Urban communities have experienced different flood types. The first strategies were mainly based on relocation during the flood and moving back after the flood event. This was under the condition when higher terrain was available and associated with extensive agricultural activities. For the places where this was not possible the houses were simply built on pillars. This first flood management strategy was based on acceptance of flood and living in flood in a quasi natural environment.

Sophistication of strategies was achieved over time and due to the growing complexity of human activities. The leading condition was to preserve the desired level of safety for urban environment and communities. With time, strategies have been institutionalized and incorporated within the legal frameworks operating at different spatial scales.

A strategy is defined as a combination of long term goals aims, specific targets, technical measures, policy instruments, and processes which are continuously aligned with the societal context (Gouldby B. at all, (2005)).

## 1.1 Approaches and frameworks for flood risk management

The European and Asian flood risk management frameworks will be analysed within this paper. In some way, the ultimate expression is formulated within the European directives produced by the European Parliament. These directives are establishing a common framework for major catchments in Europe and all the member states. The produced directives represent a holistic approach committed to water and flood management. They are considered as a major step for the development strategies and as an objective for many countries outside of the European Union zone.

All frameworks regarding flood risk management on the level of the European Union are gathered under EU Water Framework Directive and the sister directives. As a result the adaptation actions must be consistent with mitigation actions. Among the many requirements the one of the main is to require that for each river basin the integrated management plan has to be developed. This is in favour to the mitigating effects of floods.

The flood risk management in Asian countries is under the disaster risk management planning. The focus is mainly on emergency response and relief activities but the flood damages, losses to the physical environment and human population caused by floods are changing the existing approach regarding risk management. The shift in the approach in managing disasters in Asia is recognized within the global initiative of the International Strategy for Disaster Reduction (ISDR). The approach brings knowledge that disasters cannot be prevented, disasters can be reduced. The focus is on flood risk reduction through risk assessment and developing and applying strategies to treat flood risks. The risk reduction activities with purpose to mitigate and prepare people for floods are highlighted. This integrated flood risk management provides a holistic way of addressing the flood risks with respect to cooperation of stakeholders and ensuring that all phases in risk disaster cycle are covered.

With respect to European Water Framework Directive (2000/60/EC) for flood management, the flood risk is the likelihood of a flood event along with the actual damage to human life, the environment, and economic activity associated with that flood event.

From the same perspective the flood risk can be considered as a threat, more over the source of flood hazard. Further the quantification of flood risk results either in monetary units or losses in life units, if the losses are measurable, or in qualitative terms in the case of intangible damages (cultural, environmental, etc.).

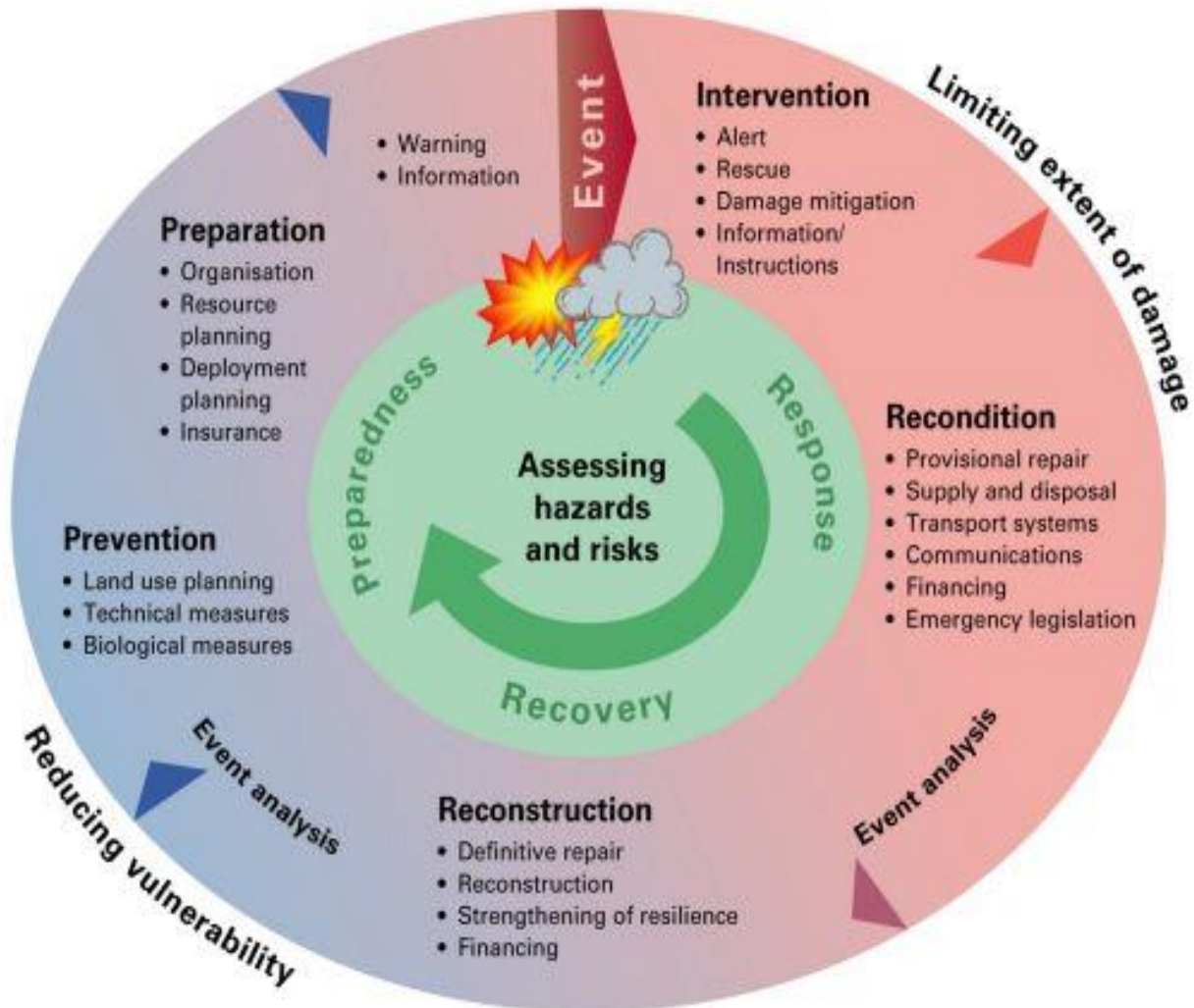


Figure 1: Risk Management Cycle (source: Integral Risk Management Cycle, FOCP 2003)

Among many flood risk definitions, one states that flood risk is unity of hazard, exposure and vulnerability (WMO, 2009, p. 5). These three components determine flood risk.

**Hazard** is defined as a potential for harm, loss or damage. It's in case of flood risk a threatening natural event where the probability/magnitude of the occurrence is included. A hazard exists where land is liable to flooding. Hazard increases with probability and depth of inundation and with the flow velocity.

The second component is **exposure** to hazard. Even where a hazard exists there is no risk unless there are assets or people that can be damaged. The exposure to flood hazard create a potential for personal danger or property damage.

The risk also depends on how vulnerable people and assets are in danger of damage. **Vulnerability** is defined as the conditions determined with physical, social, economic, or environmental factors or processes which are increasing the weakness of community to the impact of hazard (UN/ISDR, 2004). Vulnerability is a lack - or loss - of resistance to damaging forces that are coming from threat (hazard). Flood vulnerability can be minimized by taking actions before flooding and the knowledge of what action is taken in order to minimize damage and receive adequate warnings and actions during and



after a flood event. The minimization of vulnerability can be therefore does with taking appropriate precautions in advance of flooding, knowledge of what actions to take in order to minimize damage and receive adequate warnings and actions during and after a flood event.

Further the flood risk management frameworks are based and structured in line with risk management frameworks having actions that are presented with respect to temporal scales starting from event strike. This is a crucial element of risk management cycle. With this concept the systematic identification, assessment and prioritization of associated risks are covered. Further the management of measures for risk mitigation, individual phases of prevention, response, preparedness and recovery are also included. This is presented in Figure 1. The delineation between these phases is not always clear-cut.

Accordingly the **comprehensive** flood risk management has to consider all three components hazard, exposure and vulnerability. If the focus is only on risk then the procedure of managing the risk is addressed only on risk and not taking into account the environment and community. Therefore the flood risk management has to be **strategic**. A strategic flood risk management considers urban physical and social components. Consequently the flood risk management is covering:

1. Institutional framework and legal environment;
2. Implementation of strategies;
3. Social and environmental assessment.

Flood risk management mains to reduce the impact of flooding and one of the most effective approaches is through developing risk management programs incorporating preventing damage caused by flood.

Flood risk management aims to be **proactive** and that asks for, in chronological order:

1. Risk identification;
2. Development of strategies to reduce risk;
3. Creation of policies and programs to put strategies into effect.

The **integrated** flood management approach (World Meteorological Organization, (IFM 2009) is based on the principle of reducing vulnerability throughout building resilience and developing a culture of prevention. This is done through preparedness rather than by reactive responses alone. The decisions are made as a part of the ongoing science based process. This involves process that plan, act, monitor and evaluate applied strategies. The new knowledge's are then available into management approaches. This represents a shift from traditional management and view management actions as learning experiments. Integrated flood management (IFM 2009) has five stages:

- Adopting a basin approach to flood management;
- Bringing multidisciplinary approaches to flood management;
- Reducing vulnerability and risks due to flooding,
- Addressing climate vulnerability and change;
- Enabling community participation.

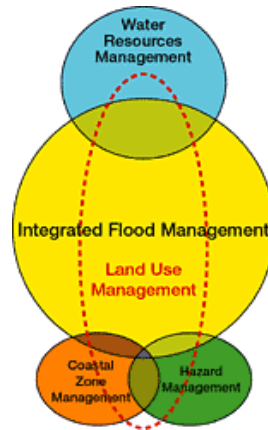


Figure 2: Integrated flood risk management (WMO & GWP (2009))

Elements of integrated flood risk management are presented in figure 2. This approach promotes integrated and not fragmented approach in managing flood risks aiming to maximize the efficient use of floodplains and to minimize loss of life.

## 2. METHODOLOGY FOR ASSESSING FLOOD RISK MANGEMENT

The flood risk management framework covers whole risk management cycle. Strategies and measures within the resist, response and recover time scale are covered. This corresponds to a temporal scale and appropriate measures implemented before, during and after a flood.

The planning process for flood risk management is driven by legislation and policy at national, regional, local and site specific levels. The flood risk management frameworks from European and Asian case studies are not unified. For European case studies all FRM frameworks are under the umbrella of the EU Flood Directive. The flood risk management in Asian countries is under the disaster risk management planning frameworks.

They are developed within different strategies in order to achieve mapped goals. The evaluation of Flood Risk Management (FRM) frameworks can be done based on the integration level of of its element.

Current frameworks focuses mainly on emergency response and relief activities but the significant flood damages and losses to the physical environment and human population caused by floods are changing the existing approach regarding risk management.

### 2.1 The maturity level

Maturity means fully developed or perfected, in general usage (Cooke-Davis, 2005). The concept is being utilized increasingly to map out logical ways to improve an organization's services. It is used in "Best Practice" benchmarks, indicating increasing levels of sophistication and other features (PMI, 2002). Maturity refers to the degree that an organization consistently carries out processes that are documented, managed, measured, controlled and continuously improved (CMMI Product Team, 2002).

The methodology proposes the development of a system-focused approach for managing the maturity of a framework and making effective and efficient decisions during an integration and implementation process.

Reflected in the flood risk management this means that is possible to 'measure' the level of coordination, integration and implementation of existing frameworks. The method is based on



evaluation of maturity of an individual flood risk management framework and view towards full integration and implementation within urban system.

The principle is to compare elements in the different frameworks with a reference level which characterizes the complexity and the efficiency of the implemented flood risk management strategy or measure. Maturity levels are determined according to reference levels which are presented within the table 1.

Maturity is encapsulated within the readiness. The readiness level is a measure that is used to assess the maturity of evolving frameworks. This is in addition to integration of frameworks and implementation of measures. The same approach for evaluation of technology is done by the US Department of Defence (DoD), National Aeronautics and Space Administration (NASA) and European Space Agency (ESA).

The system has to be fully „mature“ before it can be “ready” for use/implementation. Translated to the flood risk management there is a level that defines that framework has the capacity to go towards integration (for higher maturity) and towards resiliency. The way toward a resilience approach brings full integration and implementation of strategies and measures under the legal framework.

The highest maturity level of a flood risk management is to introduce and apply the concept of resilience in an active way: the resilience concept is introduced within the legal framework. In the same way, the EU Water Framework and Flood Directives stand as a holistic approach where for example informal way of sending information regarding flooding represents the lowest level of maturity (table 1). The readiness level of flood risk management framework is defined by the existence of a legal framework. Before reaching the highest maturity level the framework has to reach a level where all strategies and actions are built in the legal framework – the readiness level is reached (figure 3). The move to integrated level where flood risk management has a resilience approach is done through the implementation of strategies and measures on local scales.



Table 1: Maturity levels of flood risk management at city scale

<b>1 INFORMAL (AD HOC)</b>
<p><i>Short-term focus on flood risk management</i>  <i>The perception that notifying a risk is on low level</i>  <i>No standardized flood risk procedures</i>  <i>Ad hoc approaches applied on a case-by-case basis</i>  <i>No understanding or experience of flood risk management</i>  <i>No monitoring or reporting of flood risks</i>  <i>Individual actions without institutional coordination</i></p>
<b>2 BASIC</b>
<p><i>Knowledge of specific flood risks</i>  <i>Flood risk management procedures are beginning to be identified and are communicated verbally</i>  <i>High reliance on the knowledge of individuals</i>  <i>Heavy dependence on historical practice</i>  <i>Mainly individual actions with limited coordination</i></p>
<b>3 INITIAL</b>
<p><i>Midterm focus on flood risk management</i>  <i>Flood risk management policy and procedures are implementation partially</i>  <i>Some flood risk management tools and templates are developed</i>  <i>Implementation of flood risk management elements is limited to few stakeholders</i>  <i>Insurance scheme available</i>  <i>Flood maps</i>  <i>Coordination of actions by city governance</i></p>
<b>4 COORDINATED</b>
<p><i>Risks are identified</i>  <i>Best practices are incorporated into FRM framework</i>  <i>Capacity building of human resources is on high level</i>  <i>Availability of FRM tools</i>  <i>FRM implementation plan exists</i>  <i>Insurance scheme</i>  <i>Flood maps</i>  <i>Real time systems if needed</i></p>
<b>5 INTEGRATED</b>
<p><i>Resilience concept integrated within the legal framework and at the different operational scales (country to city)</i>  <i>Best practice of flood risk management – fully integrated</i>  <i>FRM framework includes and has fully application of capacity building of human resources.</i>  <i>Learn lessons are implemented in the FRM framework</i>  <i>FRM is addressing key processes</i>  <i>Insurance scheme</i>  <i>Flood maps</i>  <i>Real time systems if needed</i></p>

Table 1 represents the different levels of maturity model for flood risk management frameworks. The method is chosen after a review of different existing methods for assessing the different strategies implemented in the case study cities. The chosen methodology evaluates the maturity (complexity) level of existing flood risk management framework in case study areas. There are five different levels of maturity presented in table 1.

- The first one is an ad-hoc where there is no high risk perception. The actions are taken in an informal way. The implementation of flood risk management strategies is not assessed for the informal maturity level. Taken actions are without institutional coordination. Risk perception is on the low level.
- Second level of maturity of flood risk management framework is basic. Here the knowledge is present but just for a specific event. Procedures within flood management cycle are starting to

be identified. The risk is known just for the particular events. The reliance on knowledge of individuals is high. The actions taken to manage the risk have low institutional coordination

- Initial maturity has in consisted implementation of flood risk management policies. The institutional coordination is present. The coordination is under city governance level. The flood insurance schemes are available as well as flood maps.
- Coordinated maturity level has fully identified flood risks. Flood risk management policy and procedures integrate best practice. FRM tools and templates are available to stakeholders. FRM implementation plan exists with highly applied capacity building of human resources. Insurance schemes exist and if there is a need real time system.
- Fifth level of maturity is converging to resilience. On this level the best practice is not just a part of FRM framework but it is also fully integrated. The attitude of learning from past events is dominant. The flood risk management framework is addressing main problems.

A qualitative assessment of the different stages can be obtained by using the defined framework and evaluation of the maturity level can be produced for each strategy.

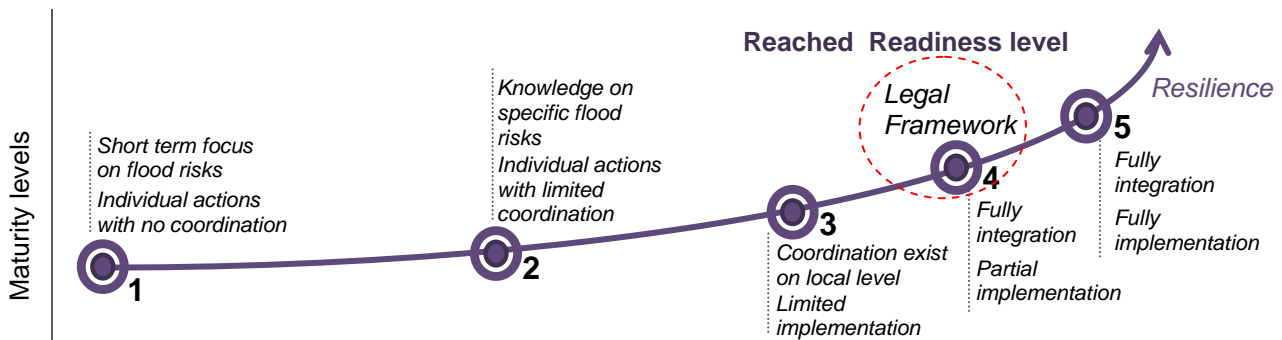


Figure 3: Theoretical curve for different maturity levels

All case studies have flood risk management frameworks. The maturity level of these frameworks is not the same. The evaluation principles are based on integration level of elements in the risk management cycle. As presented in figure 4 the framework can be fragmented with minimal coordination or fully integrated and coordinated.

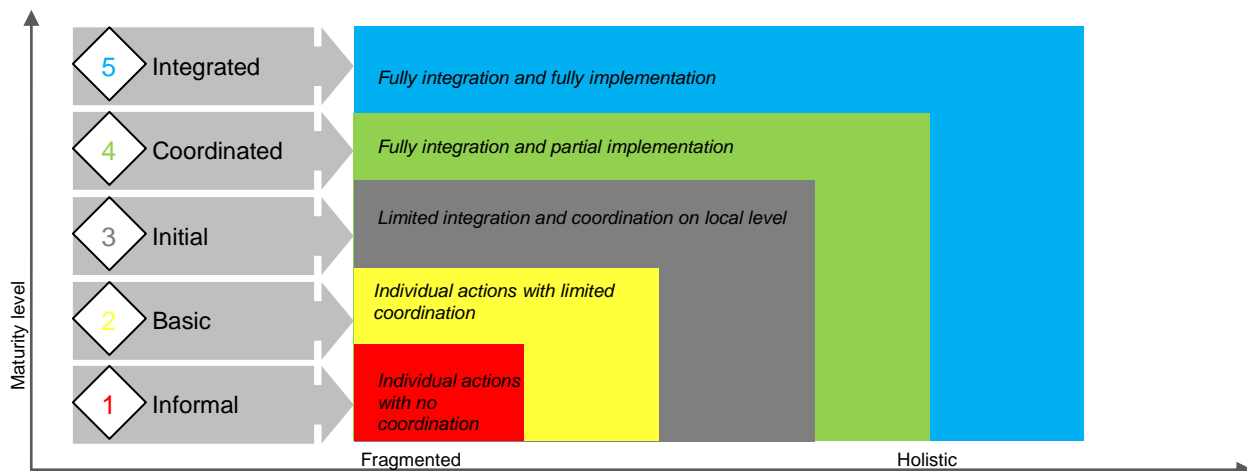


Figure 4: The maturity levels



Having in mind the differences between flood risk management frameworks the three major elements of flood risk are identified, *hazard, exposure and vulnerability*. All three represent the major principles for evaluation. Table 3 summarizes the three main components of flood risk. Based on his evaluation principles the maturity matrix is created where all elements are evaluated.

Table 3: Evaluation Principles

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<b>Flood hazard</b>
Flood control works
Structural planning and design
Asset maintenance
Operations (DSS)
<b>Exposure</b>
Land use management
Flood zoning
Land use planning
Resettlement
<b>Vulnerability</b>
Flood forecasting
Hydrological and hydraulics models
Flood hazard maps
Data acquisition network
Flood warning & emergency response
Communication system
Preparedness exercise
DSS
Post flood recovery
Support services (health, counselling)
Material support (food, shelter)
Infrastructure repairs
Financial assistance& incentives
Compensation / flood insurance
Land use management
Building regulations

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The three key elements of flood risk are chosen: flood hazard, exposure and vulnerability. These three elements present the base for every flood risk. In addition to the measures used in flood risk management are modifying one of three presented elements of flood risk.

Based on above presented key elements of flood risk is it possible to identify them in existing frameworks in the case study areas. This provides a basis for evaluation and for determination maturity levels of existing flood risk management frameworks.

The different current flood risk management strategy of case studies and its weakness is presented as well as results from maturity evaluation for each case study. The evaluation of maturity is step towards resilience approach. The resilience concept, including spatial and temporal aspects, improves flood risk management strategies.

### 3. RESULTS AND DISCUSSION

The maturity matrix is developed for the analysis of main elements in flood risk. The elements of flood risk are disaggregated into separate components and it is easy to map the weak points in existing frameworks. For each flood risk management framework the three elements are evaluated: hazard, exposure and vulnerability. The results are obtained from maturity matrix and summarized for each analysed element in the figure below. In addition the maturity level of the flood risk management framework is presented as overall value for each analysed city.

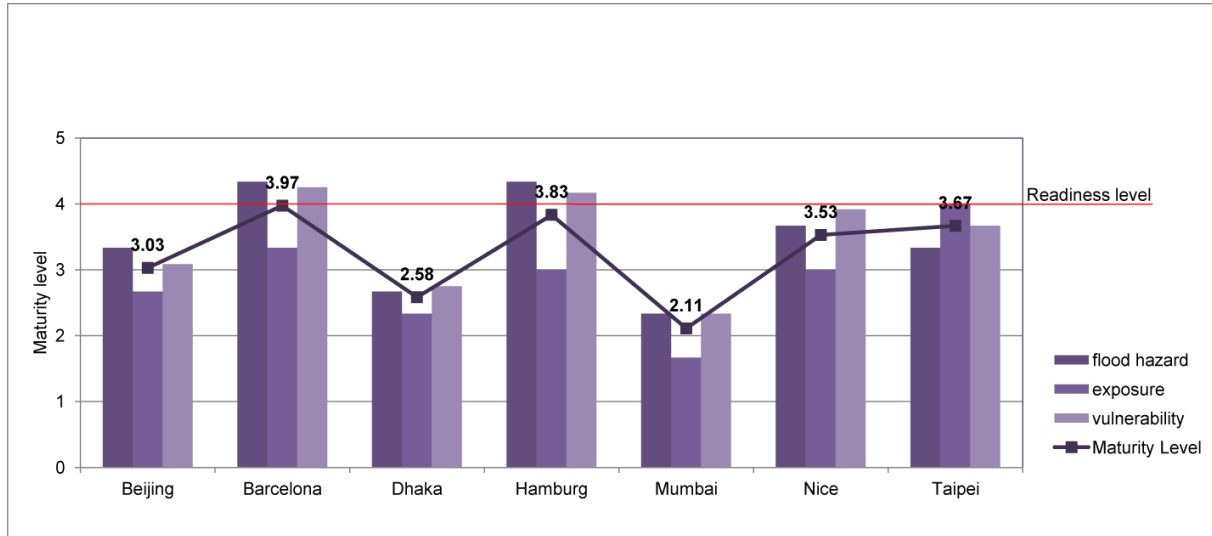


Figure 5: Results from maturity matrix for case study cities

The main scope is to identify for which flood risk management framework all actions are under the legal framework and is the framework fully implemented. The criteria provide a possibility to explore flood risk management frameworks, their integration, implementation and readiness level. The readiness level then gives a possibility to go towards achievement of resiliency.

The level of integration is obtained for each case study area in accordance with the described method. Presented results provide easy identification of weak points in existing flood risk management frameworks.

Based on defined evaluation principles for the flood hazard the following elements are analysed: flood control work, structural planning and design, asset maintenance and existing decision support systems, communication systems, integration with water resource management, environmental management. Results show that Hamburg and Barcelona have a highest integration and implementation level related to strategies and measures related to flood control.

Exposure is the second analysed element of the flood risk management framework. The results from maturity matrix shows that Taipei has the 'coordinated' maturity level considering land use management.

Strategies and measures related to flood forecasting, recovery and building regulations are in initial and coordinated level for the analysed cities. The highest level have Barcelona and Hamburg.

The lowest level considering flood hazard, exposure and vulnerability has a Mumbai case study. The existing actions are not integrated and coordinated within the framework. The knowledge on specific flood risks exist. The relevance is based on historical practice and knowledge of individuals is dominant. The actions are covered with limited coordination.

Considering all seven flood risk management frameworks it can be concluded that integration and implementation is focused mainly on flood control works where the structural planning takes the priority.

The flood risk management frameworks in Barcelona and Hamburg have reached a readiness level for flood hazard and vulnerability and they are moving toward resiliency. The actions related to land use management that are within the second element (exposure) have to be also integrated within the legal framework.

For all analysed case studies the implementation and integration related to exposure is not on high level. Therefore the flood hazard zoning, land use planning controls, resettlement and property acquisitions need to be covered with policies in order to have better implementation and coordination.



#### 4. CONCLUSION

Analysis showed that existing flood risk management frameworks are based on protection strategies where the focus is on flood prevention for the events smaller than a certain threshold (usually designed discharge or return period). The measures related to flood hazard zoning, land use planning controls, resettlement and property acquisition are not coordinated and fully implemented. In the analysed cities where they exist the actions are individual with limited institutional coordination. Further analyses should be focused on actions that will improve implementation of existing flood risk management frameworks, provide availability of flood risk management tools, incorporate best practices' into the framework.

#### 5. ACKNOWLEDGEMENTS

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