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SUMMARY

This report elaborates the developed concepts that are used in order to enrich and improve the flood management strategies in urban environments. One of the major challenges is to address the complexity of urban environments and to integrate such complexity in a new methodology able to generate efficient flood management strategy. The presented conceptual framework has three steps that are presenting a summary of the new methods and results tested on case studies in Europe and Asia.

The starting point is evaluating the maturity of existing flood risk management frameworks. The importance of this stage is in evaluation of institutional maturity for implementations and actions that are creating an environment for introducing flood resilience through institutional dimension of urban system.

Second step provide an input for evaluation. Within this step the set of measures are included into flood risk management plans. Based on defined scenarios for analysis, obtained flood maps within WP2 and evaluated flood impact (WP3) the measures are chosen to reduce the flood risk and increase flood resilience.

Third step is evaluation using the methodology for FRI developed within deliverable 4.3. Based on the matrix for FRI evaluation the flood resilience is evaluated for defined scenarios.

Also the stakeholder participation is investigated with the definition of actions necessary in process of stakeholder engagement.

Further, the SWOT analysis for the measures used in analysis is conducted. The set of measures used by case studies in order to improve flood risk management is filtered using SWOT matrix.

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2000/60/EC Water Framework Directive

2007/60/EC Flood Directive

1 CONCEPTUAL FRAMEWORK

1.1 Integration of define scenarios in flood risk assessment

Structure of work packages (WP) in CORFU project

Within defined WP1 and under deliverable 1.2 the scenarios are defined for each case study. The pathway for scenarios and the climate future for case studies contain a main narrative description and qualitative as well as quantitative socioeconomic parameters. Scenarios are covering main trends in urbanization and population of a case study area. The low/medium/high growth pathways this scenario is settled with a narrative description explaining future urbanization trends that makes a reference to the parameters listed in the socio-economic pathway below. The manifestation of each parameter is explained. The defined scenarios identify the environment for case study. The scenario with the trend for urbanization, urban growth, economy and adaptation gives the input parameters for FRI evaluation. The production of flood maps (WP2) is guided with scenarios. The output from WP2 (flood maps) have influence on spatial scale for FRI evaluation. In this sense, the scale for implementation of measures for higher flood depths is on the district and city scale, while the scale for measures against lower flood depths are based on building and parcel scale mostly. Further the outputs from WP2 are influencing outputs from WP3 where damage assessment is evaluated. The flood risk assessment and inputs from WP's are shown in the figure below. The presented path from WP1 to WP4 reflects the complexity of resilience assessment. Starting from scenario definition and taking into account the simulation of flooding, calculating the flood damages the last part under the WP4 consider a lot of different factors that influence the process of assessment of flood risk management. The assessment flood resilience for urban systems has an integrative character. An integrative approach combines different elements into whole.

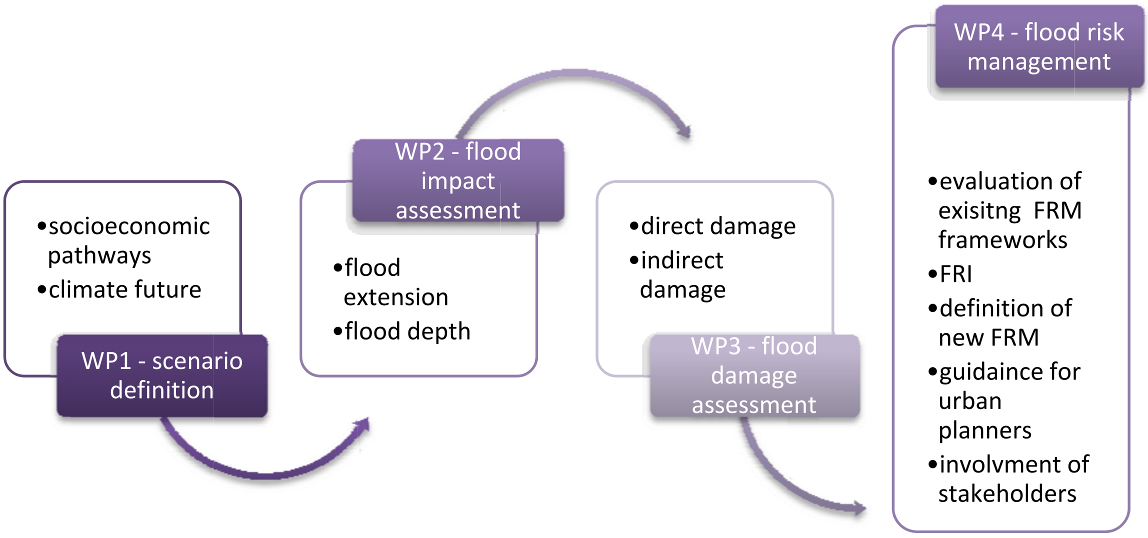

Figure 1: The pathway from WP1 to WP4 and its complexity (CORFU project)

The report focuses on main conclusions and recommendations of all applied methods and tools used in analysis, assessment of flood risk management in case study areas. Within WP4 the analysis starts with case study introduction. This count all necessary information related to historical floods, existing standards, and institutional frameworks, economic and social condition.

1.2 Defining flood risk

The flood risk management in most Asian countries is often considered under the umbrella of disaster risk management planning (ADPC, 2005). The focus is mainly on emergency response and relief activities but the damages and huge flood damages and loses to physical environment and human population caused with 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 manage flood risk. The risk reduction activities that are aimed at mitigating flood risk and preparing people for floods are highlighted. Integrated flood risk management provides a holistic way of addressing flood risk with respect to the cooperation of stakeholders and ensuring that all phases in the disaster risk 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 its adverse consequences, including the loss of human life, damage to the environment, and economic impacts through reduction in activity.

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

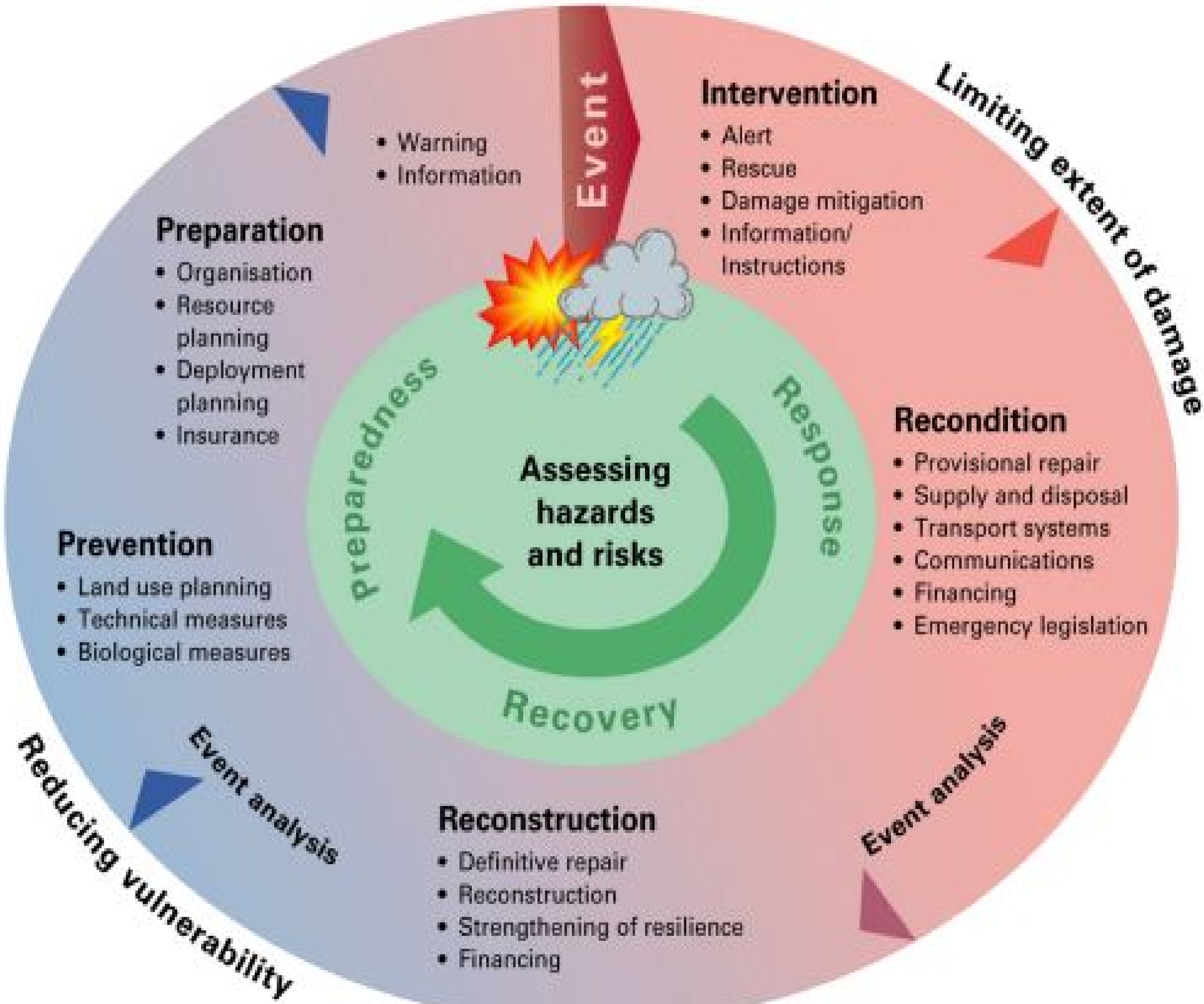

Figure 2: Risk Management Cycle (source: Integral Risk Management Cycle, FOCP 2003)

The framework for flood risk management begins with the definition of 'flood risk'. There is no single definition for flood risk but the one that is very useful to start from says that flood risk is unity of hazard, exposure and vulnerability (Kron, 2005). These three components determine flood risk.

Hazard is defined as the potential for harm, loss or damage. In the case of flood risk, it is the threatening natural event including its magnitude and probability of occurrence. Hazard exists where land is liable to flooding. Hazard increases with probability, with flood depth, and with 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 creates the potential for personal danger or property damage to property.

The risk also depends on how vulnerable people and assets are in danger of damage. **Vulnerability** is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UN/ISDR, 2004). Vulnerability is a lack - or loss - of resistance to damaging forces that are coming from a threat (hazard). Flood vulnerability can be minimized by taking actions before flooding and knowledge of what action to take in order to minimize damage and receive adequate warnings and actions during and after flood event.

Further 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 before the onset of the event and continue through to the recovery phase. This is a crucial element of the 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 **comprehensive** flood risk management has to consider all three components: hazard, exposure and vulnerability. Also, the focus should be also on the environment and community which gives it a **strategic** characteristic. Strategic flood risk management considers physical and social components of the urban environment. Consequently it covers:

1. The institutional and legal framework
2. Implementation of strategies
3. Social and environmental assessment

Flood risk management aims to reduce the impact of flooding and one of most effective approaches is through developing risk management programs that incorporate the prevention or reduction of flood damage.

Flood risk management aims to be **proactive** and that requires the following steps:

1. Risk identification
2. Development of strategies to reduce risk
3. Creation of policies and programs to implement strategies

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 processes that plan, act, monitor and evaluate applied strategies. The new knowledge is then available and incorporated into management approaches. This represents a shift from traditional management, and rather views 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.

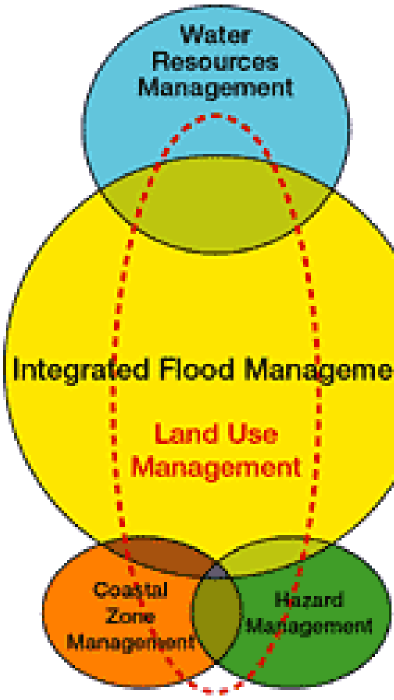

Figure 3: Integrated flood risk management (WMO, 2009)

Elements of integrated flood risk management are presented on figure 2. This approach promotes integrated instead of a fragmented approach to managing flood risk, and aims to maximize the efficient use of floodplains and to minimize loss of life.

Following analysis conducted in reports 4.2, 4.4, 4.5 and 4.6 the conceptual framework is created.

The flood resilience assessment is done through different stages. Considering urban environments as urban systems, with main elements - urban cells the system is presentated as set of:

(i) Urban functions (Figure 4)

(ii) City services (Figure 4)

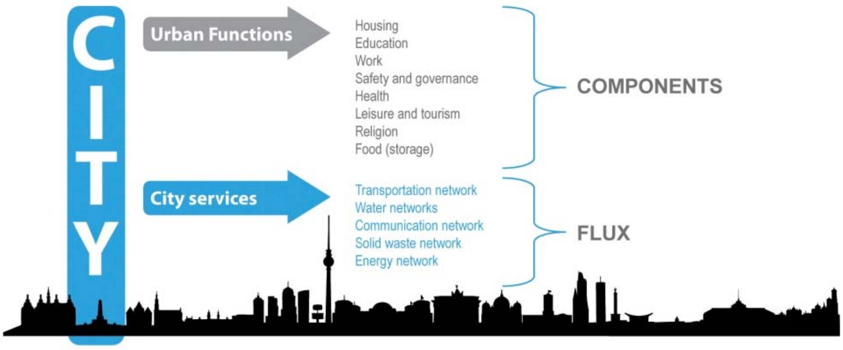

Figure 4: Urban functions and services in urban system

The level of disturbance and damage caused by flood is to be examined in order to evaluate the flood resilience levels. The framework has four stages presented in figure below. The starting point is evaluating the maturity of existing flood risk management frameworks. The importance of this stage is in evaluation of institutional maturity for implementations and actions that are creating an environment for introducing flood resilience through institutional dimension of urban system.

Second step provide an input for evaluation. Within this step the set of measures are included into flood risk management plans. Based on defined scenarios for analysis, obtained flood maps within WP2 and evaluated flood impact (WP3) the measures are chosen to reduce the flood risk and increase flood resilience.

Third step is evaluation using the methodology for FRI developed within deliverable 4.3. Based on the matrix for FRI evaluation the flood resilience is evaluated for defined scenarios.

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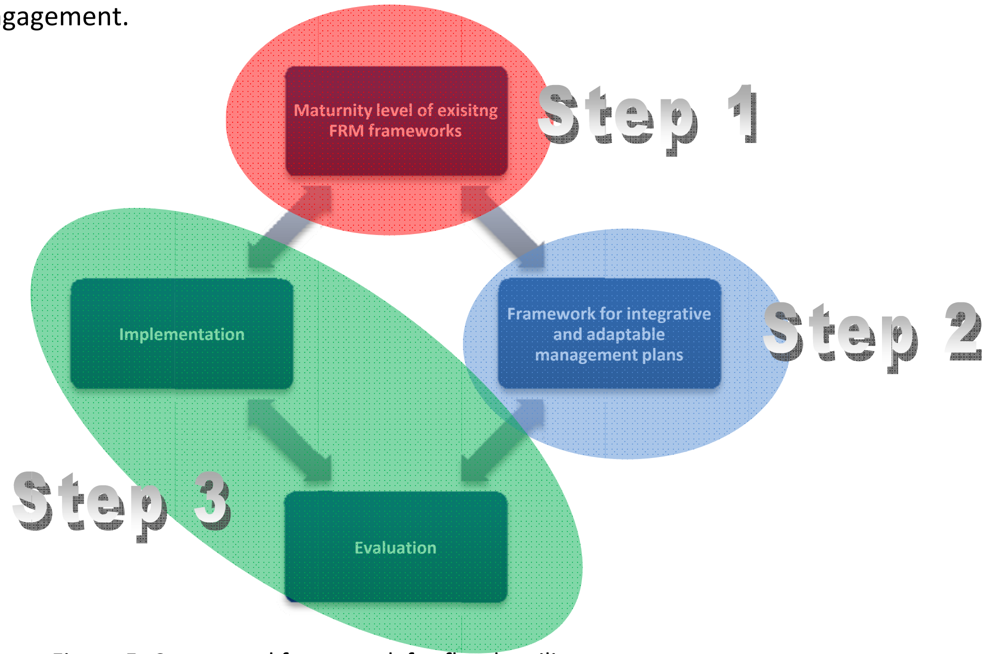

Figure 5: Conceptual framework for flood resilience assessment

1.2.1Step 1

For each case study area a flood event is analyzed. The structural and non-structural measures are observed as well as existing flood risk management frameworks with the legal structure. Further the analysis of different maturity for flood risk management frameworks is done. The main scope is to identify integration and implementation of measures. The results are presented in theTable 1.

The three main elements for flood risk management are considered: flood hazard, exposure and vulnerability for choosing case study areas. The main criteria explore flood risk management frameworks integrated and reached the readiness level with the level of implementation achieved..

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.

Results provide identification of weak points in existing flood risk management frameworks. The evaluation that is taking into account elements of risk (hazard, exposure and vulnerability) disaggregated into separate components gives possibility to map the weak points in existing frameworks.

The results are obtained from maturity matrix and summarized for each analyzed element in the figure below. In addition the maturity level of the flood risk management framework is presented as overall value for each analyzed city.

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

Based on defined evaluation principles for the flood hazard the following elements are analyzed: 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 analyzed element of the flood risk management framework. The results from the maturity matrix show 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 analyzed cities. The highest level has Barcelona and Hamburg.

The Mumbai case study has the greatest exposure to flood hazard and highest vulnerability of all the case study cities. 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 the analyzed 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.

Analysis shows that existing flood risk management frameworks are based on protection strategies focusing 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 analyzed 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.

The way toward resilience approach brings fully integration and implementation of strategies and measures under the legal framework. Evaluation of resiliency of physical environment and urban communities to certain flood events is expressed with flood resilience index. The flood resilience index is represented as a level of flood resilience assessment in analyzed area and for certain flood characteristics.

Table 1: Maturity levels for existing flood management frameworks in European and Asian case studies

	Beijing (China)	*Barcelona (Spain)*	*Dhaka (Bangladesh)*	*Hamburg (Germany)*	*Mumbai (India)*	*Nice (France)*	*Taipei (Taiwan)*
FLOOD HAZARD							
Flood control works							
Structural planning and design	4	4	3	4	3	4	4
Asset maintenance	3	5	3	5	2	4	3
Operations (DSS)	3	4	2	4	2	3	3
EXPOSURE							
Land use management							
Flood zoning	3	5	3	4	2	4	4
Land use planning	4	4	3	4	2	4	4
Resettlement	1	1	1	1	1	1	4
VULNERABILITY							
Flood forecasting							
Hydrological and hydraulics models	3	5	5	5	2	4	4
Flood hazard maps	4	5	5	5	2	5	4
Data acquisition network	4	4	5	4	1	4	4

Flood warning & emergency response							
Communication system	*3*	*5*	*1*	*5*	*3*	*4*	*4*
Preparedness exercise	*3*	*4*	*2*	*5*	*3*	*3*	*4*
DSS	*3*	*4*	*3*	*4*	*3*	*4*	*4*
Post flood recovery							
Support services (health, counselling)	*3*	*4*	*3*	*4*	*3*	*4*	*4*
Material support (food, shelter)	*3*	*4*	*3*	*5*	*3*	*4*	*3*
Infrastructure repairs	*4*	*5*	*2*	*5*	*3*	*5*	*4*
Financial assistance& incentives	*3*	*4*	*2*	*4*	*2*	*4*	*3*
Compensation / flood insurance	*1*	*4*	*1*	*2*	*1*	*3*	*2*
Land use management							
Building regulations	*3*	*3*	*1*	*2*	*2*	*3*	*4*
MATURITY LEVEL	3.06	4.11	2.67	4.00	2.22	3.72	3.67

The maturity levels	
>1	Informal
>2	Basic
>3	Initial
>4	Coordinated
5	Integrated

1.2.2Step 2

After defining the sets of measures in the analyzed case study areas, it is easy to conclude that the flood risk management plans include (i) flood probability reduction measures and (ii) flood vulnerability and impact minimization measures. Taking into account different spatial scales the proposed measures focus on (i) urban scale (case study area), (ii) catchment scale, (iii) district, (iv) neighborhood, (v) block and (vi) parcel/property/building scale. The diversity of different scales is summarized in the table below along with corresponding measures for each case study.

The chosen measures in Asian case study are targeting bigger scales (catchment and urban scale) which is corresponding to the big flood extend and flood duration. The range of measures for European case studies focuses on macro, mezzo and micro scale. The interventions related to measures for Asian case studies are focusing on big systems, e.g. drainage system, retention areas and ponds (in Dhaka) while in European case studies the impact of chosen measures is to be analyzed at smaller scales (parcel/property/building). This can be connected with potential cost of chosen measure. Hence, this is not an objective of this report so further considerations will not be made regarding the cost of measures.

The draft of flood risk management plans in case study areas is therefore completed with the presented sets of measures for different scales.

It is important to mention that the huge role in implementation has an involvement of stakeholders and policy makers.

The ability of presenting in a proper way the effectiveness of measures to stakeholders and policy makers should have priority while trying to improve mentality regarding possible solutions to decrease the flood impact. With the implementation of flood resilience measures through developing flood insurance schemes, comprehensive flood management planning, developed evacuation routes, communication with the population and many others the resilience of urban areas will have increased trend. Increased resilience implies reduced damages caused by flood, the possibility of the system (urban area) to be recovered faster after flood strikes, the possibility of a system to accept change in order to cope with flooding processes.

Table 2: Chosen flood probability reduction and flood vulnerability and impact minimization measures in case study areas

Case study	Scale					
	Catchment	Urban	District	Neighborhood	Block	Property/Parcel/building
Hamburg	Restoration of watercourses: •Polders, ponds & wetlands •Flood plains restoration •Controlled conveyance	Capacity building of the key stakeholders •Land use control •Spatial planning •Building regulations •Contingency planning and infrastructure •Recovery •Financial preparedness		Multifunctional spaces •Large SUDS •Swales •Controlled Conveyance •Bioretention areas •Retention & infiltration basins •Flood barriers Flood proofing of built environment (resilient systems) •Capacity building of communities		Water harvesting units •Allotment SUDS •Filter trances •Green roofs •Pervious pavements •Flood proofing of buildings •Capacity building of dwellers
Dhaka	Retention ponds Pump stations Capacity building of the key stakeholders •Land use control •Spatial planning •Building regulations •Contingency planning and infrastructure •Recovery •Financial preparedness Flood proofing of buildings •Capacity building of dwellers					

Case study	Scale					
	Catchment	Urban	District	Neighborhood	Block	Property/Parcel/building
Nice		Capacity building of stakeholders Deployment of flood resilient technology Contingency measures • Evacuation and rescue plans • Forecasting and warning services • Control emergency operations • Provision of emergency response staff	Capacity building of stakeholders Deployment of flood resilient technology Contingency measures • Evacuation and rescue plans • Forecasting and warning services • Control emergency operations Provision of emergency response staff			• Wed and dry flood proofing Raised porch/threshold Auto-barriers Water-resisting external doors/windows Sealant around external doors/windows • Raising thresholds - Remove vulnerable items from flood risk Raised utilities Raised kitchen appliances Removable fixtures and fittings Relocate valuables Watertight covers for values
Taipei		• Pumping station • Drainage System Maintenance • Flood/Hazard information centers • Education • Library resources • Web-based learning • Training	• Pumping station • Drainage System Maintenance • Flood/Hazard information centers • Education • Library resources • Web-based learning • Training			
Barcelona			Increasing capacity of drainage systems Adding additional pipes			Dry proofing • flood door • sand bags • brick wall • shutter door Green roofs
Beijing			Yizhuang : Existing pipeline network reconstruction • New pipes • Two retention areas • Four pump stations • Four storage tanks • Heightening and strengthening embankment of existing rivers • New channels			

Application of proposed index and results on the case study areas is presented within this chapter. With respect to different data available in case study areas the methodology is applied on (i) parcel/building scale, (ii) city/district scale or (iii) both scales. It is important to stress that it was not possible to obtain all of data regarding the services in the city especially for energy and communication network therefore we proceed with some assumptions.

1.2.3Step 3

Within this step the analysis and evaluation is done in order to calculate FRI. Focusing on different scales the FRI is evaluated for Hamburg, Nice, Barcelona, Taipei and Beijing case study areas. Depending on chosen scale, level of data available and obtained results from damage modeling, urban growth, economic analysis, hydraulic modeling and considered scenarios the FRI values are presented in form of

(i) Tables

(ii) Radar charts

(iii) Maps within GIS

The testing of developed method for FRI was done for different measures and according the flood risk management planning in case study area. Difference in approach and result presentation is due to the diversity of the flooding in case studies at the first place and on the case study teams that conducted analysis. It is important to note that the method for FRI is set as a tool for calculating flood resilience level at the particular case study with the particular flood characteristics. This is result of dynamic of the flood resilience itself. Following this report the set of conclusions and recommendations for the case study area regarding increasing flood resilience will be within this report.

Barcelona

Baseline scenario

Once the methodology is defined, it is applied to the baseline scenario representing the current situation of the Raval district. As stated earlier, some indicators can be left out from the analysis when no data are available or a definite value can't be assigned. This is precisely what happened in this case, in which several indicators were not considered.

For all the other indicators, a value was given. The Barcelona case study partners did two independent assessments for each scenario that afterwards were averaged to obtain the final FRI value. The overall FRI for the baseline scenario was the first one calculated. In **Error! Reference source not found.**, an overview of the FRI assessment done by "Evaluator #1" can be seen, presenting a detailed summary of the FRI for each dimension. The same results are presented in Table 4, for the evaluation carried out by "Evaluator #2". Then, by averaging the results of the two tables, the value of the FRI assumed under present conditions is of **3.58**.

Table 3: Assessment of the FRI by "Evaluator #1" in the Raval district for the baseline scenario (2010)

Dimension	Indicators	∑wi	∑(xi*wi)	Dimension index ∑((xi*wi)/ ∑wi)	Weight	Overall FRI
Natural	2	10	35	3.50	4.67%	3.50
Physical	26	86	313	3.64	40.19%	
Social	8	24	78	3.25	11.21%	
Economic	11	32	119	3.72	14.95%	

Institutional	20	62	203	3.27	28.97%	

Table 4: Assessment of the FRI by "Evaluator #2" in the Raval district for the baseline scenario (2010)

Dimension	Indicators	∑wi	∑(xi*wi)	Dimension index ∑((xi*wi)/ ∑wi)	Weight	Overall FRI
Natural	2	10	35	3.50	4.41%	3.67
Physical	28	94	350	3.72	41.41%	
Social	8	24	99	4.13	10.57%	
Economic	11	32	128	4.00	14.10%	
Institutional	22	67	220	3.28	29.52%	

Business as usual scenarios

After the assessment of the FRI for the current situation, the same assessment was done for the two businesses as usual scenarios. The BAU1 scenario, presenting a pessimistic climate change situation is presented in Table 5 and Table 6 (showing the assessments of both evaluators). On the other hand, Table 7 and Table 8show the results of the FRI for the BAU2 scenario, that considers an optimistic climate change situation.

Table 5: Assessment of the FRI by "Evaluator #1" in the Raval district for the BAU1 scenario (2050)

Dimension	Indicators	∑wi	∑(xi*wi)	Dimension index ∑((xi*wi)/ ∑wi)	Weight	Overall FRI
Natural	2	10	27.5	2.75	4.67%	3.40
Physical	26	86	296	3.44	40.19%	
Social	8	24	78	3.25	11.21%	
Economic	11	32	122	3.81	14.95%	
Institutional	20	62	205	3.31	28.97%	

Table 6: Assessment of the FRI by "Evaluator #2" in the Raval district for the BAU1 scenario (2050)

Dimension	Indicators	∑wi	∑(xi*wi)	Dimension index ∑((xi*wi)/ ∑wi)	Weight	Overall FRI
Natural	2	10	25	2.50	4.41%	3.34
Physical	28	94	304	3.23	41.41%	
Social	8	24	99	4.13	10.57%	
Economic	11	32	125	3.91	14.10%	
Institutional	22	67	206	3.07	29.52%	

Table 7: Assessment of the FRI by "Evaluator #1" in the Raval district for the BAU2 scenario (2050)

Dimension	Indicators	∑wi	∑(xi*wi)	Dimension index ∑((xi*wi)/ ∑wi)	Weight	Overall FRI
Natural	2	10	35	3.50	4.67%	3.51
Physical	26	86	311.5	3.62	40.19%	
Social	8	24	78	3.25	11.21%	
Economic	11	32	122	3.81	14.95%	
Institutional	20	62	205	3.31	28.97%	

Table 8: Assessment of the FRI by "Evaluator #2" in the Raval district for the BAU2 scenario (2050)

Dimension	Indicators	∑wi	∑(xi*wi)	Dimension index ∑((xi*wi)/ ∑wi)	Weight	Overall FRI
Natural	2	10	35	3.50	4.41%	3.76
Physical	28	94	357	3.80	41.41%	
Social	8	24	114	4.75	10.57%	
Economic	11	32	128	4.00	14.10%	
Institutional	22	67	220	3.28	29.52%	

In order to compare the evolution of the FRI, the differences between the baseline scenario and the two BAU scenarios are shown in **Error! Reference source not found.**. The values have been calculated using the averaged assessments of the two evaluators. As it can be seen, BAU1 scenario presents a considerable decrease of the FRI whereas BAU2 shows a slight increase, although the result is practically the same as for the baseline. The averaged FRI values per dimension can also be seen in Figure 6.

Table 9: FRI for the baseline and BAU scenarios, with their respective percentage of change

Scenario	Overall FRI	% of change
Present state	3.58	-
BAU1	3.37	-5.76%
BAU2	3.64	1.58 %

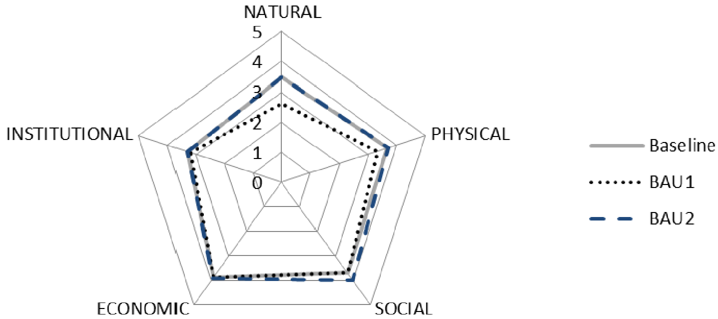

Figure 6: Comparison of the FRI values per dimension for the baseline and BAU scenarios

According to "Evaluator #1", BAU1 scenario affects 11 indicators of the 67 used in the baseline scenario, whereas BAU2 scenario only affects 4 indicators. On the other hand "Evaluator #2" introduced changes in 22 indicators (out of 71) for BAU1 and 7 for BAU2.

The business as usual scenarios have been built considering changes in land-use, economic growth and climate. The first two were defined as constant in the two scenarios, and in general, imply small changes in the future conditions (which are expressed by the 4 indicators described by "Evaluator #1" and the 7 of "Evaluator 2"). For the last variable, the climate, changes are considered differently in both scenarios: BAU1 uses a pessimistic climate change scenarios, with important increases in the rainfall intensities, whereas BAU2 uses the same rainfall as in the current situation. Therefore, the BAU1 scenario affects considerably the natural and physical dimensions, while BAU2 does not modify them. This clearly explains the different trends that the two BAU scenarios showed in **Error! Reference source not found.**.

Adaptation scenarios

The measures defined for adaptation scenarios have been assessed using the FRI. As before, two evaluators have done independent assessments for each one of the six adaptation scenarios considered. For the sake of brevity, the results of the several adaptation scenarios have been aggregated, so a smaller amount of tables is provided. In Table 10 and Table 11, the results of the several dimensions and the final FRI for each of the scenarios can be seen, for the two different evaluators. In addition, these values are represented graphically in Figure 7.

Then, these values are further aggregated in Table 12, so the changes with respect to the baseline and the corresponding BAU scenarios can be observed. In this way, the performances of the implemented strategies can be assessed, determining the resilience increases expressed by the FRI.

Table 10: Assessment of the FRI of the adaptation scenarios by "Evaluator #1" in the Raval district

Dimension	Adaptation1	Adaptation2	Adaptation3	Adaptation4	Adaptation5	Adaptation6
Natural	4.25	4.00	4.50	4.75	4.25	4.75
Physical	4.09	3.74	4.33	4.27	3.92	4.49
Social	4.38	3.81	3.50	4.25	3.81	3.50

Economic	4.06	3.94	3.98	3.97	3.94	3.98
Institutional	4.19	3.80	3.60	4.19	3.80	3.60
FRI	**4.15**	**3.81**	**3.98**	**4.22**	**3.89**	**4.06**

Table 11: Assessment of the FRI of the adaptation scenarios by "Evaluator #2" in the Raval district

Dimension	Adaptation1	Adaptation2	Adaptation3	Adaptation4	Adaptation5	Adaptation6
Natural	2.50	4.50	4.00	3.50	4.50	4.00
Physical	4.07	3.47	4.05	4.27	3.56	4.05
Social	4.75	4.50	4.25	4.75	4.75	4.75
Economic	4.28	3.91	3.91	4.00	4.00	4.00
Institutional	3.85	3.40	3.07	3.85	3.28	3.28
FRI	**4.04**	**3.67**	**3.76**	**4.12**	**3.71**	**3.89**

Table 12: FRI values for all the scenarios and percentages of increase with respect to the baseline and the corresponding BAU scenarios

	FRI			% average increase	
Scenario	Evaluator #1	Evaluator #2	Average	% increase baseline	% increase BAU
Baseline	3.50	3.67	3.58	-	-
BAU1	3.40	3.34	3.37	-5.76	-
Adaptation1	4.15	4.04	4.10	14.43	21.43
Adaptation2	3.81	3.67	3.74	4.37	10.76
Adaptation3	3.98	3.76	3.87	8.14	14.75
BAU2	3.51	3.76	3.64	1.58	-
Adaptation4	4.22	4.12	4.17	16.55	14.73
Adaptation5	3.89	3.71	3.80	6.16	4.51
Adaptation6	4.06	3.89	3.97	11.00	9.27

From the values that can be seen in the previous tables, it is clear that the several adaptation scenarios improve the resilience of the studied are with respect to the BAU scenarios. The increases of the FRI values for the adaptation scenarios range between 4.5 and 21.4 %.

It is observed that the strategy that provides higher increases of the FRI is the one expressed in scenarios Adaptation 1 and 4. For this strategy, a EWS is implemented, as well as local protection measures, education and awareness campaigns and the creation of a risk culture. This package of non-structural strategies mainly focuses on reducing the vulnerability. Consequently, although the hazard and hence the natural dimension is not as much affected as it is with other strategies, all the other dimensions are considerably improved, leading to FRI over 4 for all the situations (for the optimistic and pessimistic climate scenarios, and the two evaluations).

The structural strategies implying new pipes and one storage tank are the ones that have the second highest values of the FRI. In this case, the highest increases are shown in the natural and physical dimensions. This is so, because the classical structural strategies applied mainly focus on the hazard reduction. Finally, the SUDS are the strategies that have been considered that present smaller increases of the FRI. However, the FRI increases are around 10%, which means that their performance is still very good. This is explained by the fact that these strategies affect all the dimensions, but in a moderate way.

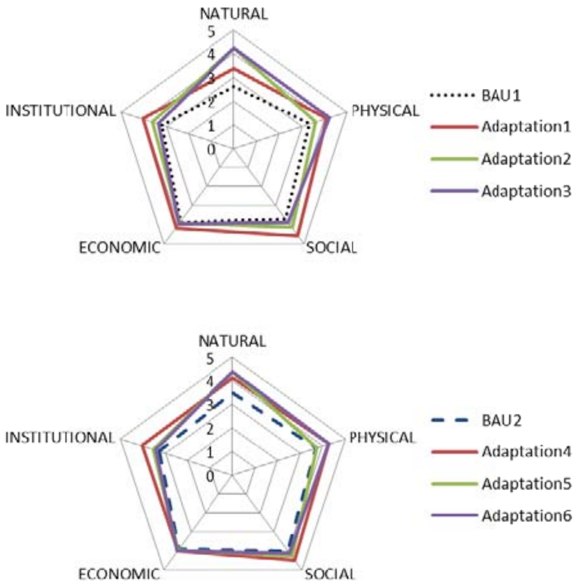

Figure 7: Comparison of the FRI values per dimension for the pessimistic (left) and optimistic (right) climate change scenarios

As it was observed in section 0, the effects of the two climate change scenarios used imply important differences in the scenarios BAU1 and BAU2. Given that the FRI of BAU1 is smaller than the one of BAU2, the adaptation scenarios 1, 2 and 3 also present, respectively, smaller FRI values than the 4, 5 and 6. However, the relative increases of FRI that can be seen in Table 12, show that in general, the strategies perform in the same way whatever the climate scenario is used. This means that all these strategies are robust, being able to function with different plausible climate situations.

Beijing

The FRI evaluation for Beijing case study focuses on Yizhuang area. The FRI assessment is conducted for property, block and district scale.

The FRI values on building scale where urban functions are considered have a range of value from 0.71 to 4.95. A very low value of FRI is due to missing availability of evaluated requirement at certain flood depth. On the other side the value of 4.95 correspond to very small flood depths and high availability level of requirement.

For FRI calculation at district scale the developed matrix is used with 91 indictors. The calculation is done for two different states: (i) present and (ii) future 2050. The obtained values shows two different values of FRI respectively 2.46 and 2.48. Very small difference is due to the fact that measures are not included in evaluation. The considered change in land use is contributing to the increase of FRI for 2050 year. The conclusion can be that the land use planning which is a part of flood preparedness measures is contributing to increase of FRI for chosen area.

Hamburg

A summary with the FRI values at all scales and for all scenarios (including the scenarios with the implemented measures as a part of the FRMP) is shown in Table 13.

The values of the FRI decrease each time the scale is lowered. Such effect is the result of specific areas being selected if they were affected by flooding, precisely to determine if an FRI at a large scale can significantly reflect the FRI of a subscale.

In general, the implementation of the measures on the scenarios improves the FRI value. However, it is difficult to observe the influence of the measures at the borough- and property scales' calculated FRIs. This issue rises from the lack of indicators that integrate the catchment-scale with the borough- and property scales.

The results of the property and the neighbourhood scales are lower than the catchment value. While the general FRI is 4.27 and for the borough of Tonndorf is 4.13, the properties in that borough have characteristics that lower their FRI values to 2.88 and 3.5. This shows that, although the general system might be resilient at the catchment and the borough - scales, some of its components at the property-scale might not be as resilient and requires attention.

In the case of the overall FRI, the inclusion of a set of the measures provides the best flood resilience performance for the natural dimension. S3 presents the best value for the social dimension, thus the implementation of a set of measures does not provide any change to it. Physical and economic dimensions remain fairly stable from one scenario to another so the focus can be directed to the other three dimensions of the FRI (seeFigure 8).

Table 13: General results for all scales

	Scenario			
Catchment	Present	S1	S2'	S2
Wandse Catchment	4.27	3.79	4.19	4.63
Neighbourhood	Present	S1	S2'	S2
Eilbek	4.75	4.5	4.56	4.75
Tonndorf	4.13	3.82	3.88	4.23
Wandsbek	4.75	3.56	4.19	4.81
Property	Present	S1	S2'	S2

ID1	2.88	2.5	2.63	3.13
ID2	3.5	3.19	3.44	3.88

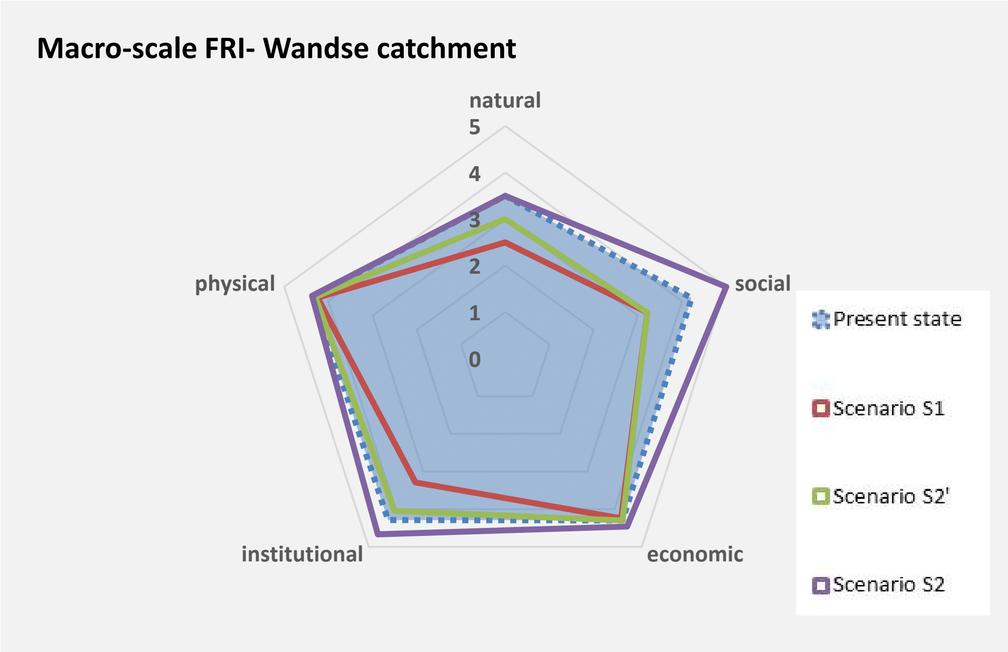

Figure 8: Comparison of all scenarios' overall FRIs per dimension

In terms of neighbourhood FRIs, the measures to be implemented have no significant impact in changing the FRI, except in the case of Wandsbek, where the most changes within the availability of requirements are observed. However, it can be appreciated that the current state does not defer much from the best-performing scenario (S2). An overview of the obtained results for the Wandsbek borough is given in Figure 9.

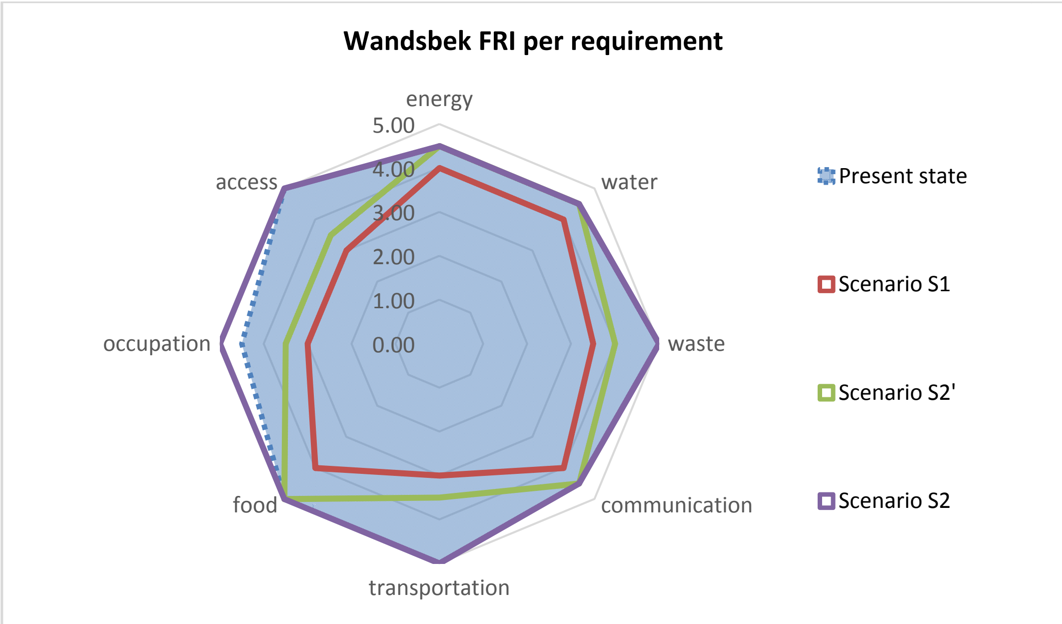

Figure 9: Scenarios comparison of requirements for Wandsbek

The analyzed buildings for the property scale obtained lower values of FRI than the neighbourhood and catchment scales (**2.88** and **3.5**, for ID1 and ID2 respectively in comparison to **4.13** and **4.27** for the neighbourhood and catchment scales respectively).It confirms the necessity to deploy a multiple scale approach and analyze the elements of an urban environment in different contexts in order to assess their actual performance in an urban system.

The FRI method went beyond the mere cost benefit analysis and pointed out a few additional features a property/borough or the whole system are to consider or improve (e.g. the accessibility of the properties during floods, access to resources in the post disaster recovery etc..) in order to cope better with floods. For the consistency of the assessment, the same group of experts or stakeholders should perform the analysis for the situation with and without adaptive strategies. In that way, it is possible to mitigate the subjectivity error by adding the same level of the subjective thinking to both scenarios.

Nice

A summary of the results for all scenarios and taking into account different scales is presented in table below.

FRI Urban, city scale						
Scale		BAU	S1	S2	S3	S4
Without measures		3.45		3.45	3.45	3.42
With measures		No measures		3.73	4.10	No measures
Without measures			3.45			
With measures			3.71			
FRI Property/building scale without measures						
		0.2	0.5	1m	>1.5m	
Housing	Flooded UF Without measures	3.85	3.59	2.81	2.41	
Working		3.88	3.46	3.19	2.12	
Safety&administration		3.90	3.60	3.00	2.13	
Health		3.88	3.63	2.88	2.63	

Food		3.86	3.62	3.00	2.29	
Leisure&tourism		4.00	3.82	3.35	3.12	
Religion&cemetary		4.00	3.88	3.59	3.59	
Education		3.42	3.08	2.71	2.71	
Transportation		4.00	3.60	2.87	2.13	
Housing	Non-flooded Without measures	4.30	4.15	4.07	3.30	
Working		4.31	4.15	4.04	3.31	
Safety&administration		4.33	4.20	4.03	3.37	
Health		4.25	4.13	3.63	3.25	
Food		4.18	3.76	3.24	2.86	
Leisure&tourism		4.24	4.06	3.88	3.76	
Religion&cemetary		4.24	4.24	4.06	3.94	
Education		4.38	4.04	3.96	3.88	
Transportation		4.47	3.60	3.30	3.03	
FRI Property/building scale with measures (flood preparedness)						
		0.2	0.5	1m	>1.5m	
Housing	Flooded UF With measures	4.22	3.96	3.33	2.41	
Working		4.23	3.65	3.50	2.12	
Safety&administration		4.30	4.00	3.40	2.13	
Health		4.25	4.00	3.25	2.63	
Food		4.18	3.67	3.10	2.29	
Leisure&tourism		4.29	4.00	3.76	3.12	
Religion&cemetary		4.29	4.18	4.12	3.59	
Education		4.33	4.21	4.04	2.71	
Transportation		4.00	3.60	2.87	2.13	
Housing	Non-flooded With measures	4.30	4.15	4.07	3.30	
Working		4.31	4.15	4.04	3.31	
Safety&administration		4.33	4.20	4.03	3.37	
Health		4.25	4.13	3.63	3.25	
Food		4.18	3.76	3.24	2.86	
Leisure&tourism		4.24	4.06	3.88	3.76	
Religion&cemetary		4.24	4.24	4.06	3.94	
Education		4.38	4.04	3.96	3.88	
Transportation		4.47	3.60	3.30	3.03	

There is a significant increase in FRI value for the implementation of flood preparedness measures on property/building level. Obtained FRI values indicate the direct connection of internal requirement for urban function. With proposed measure the flood water is not entering house and the character of the urban function remain the same. The focus is on the external requirement. The social component of this is important, since, the urban function can be used during flood event and it is safe for occupants. The FRI level is therefore fully deepens on external requirements.

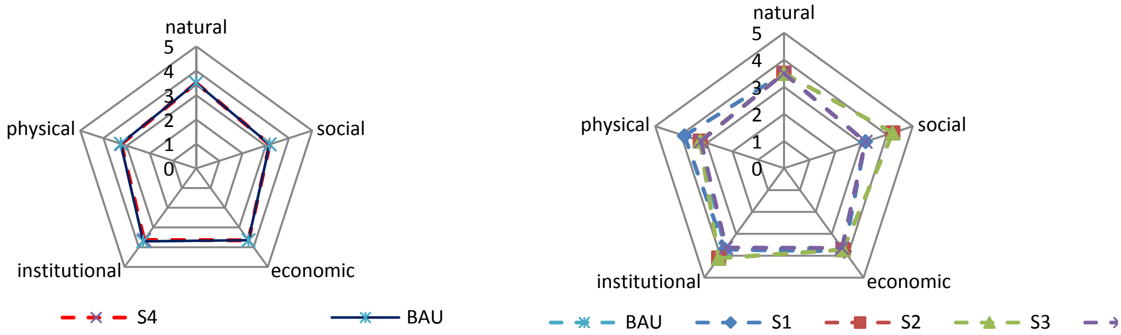

Figure 10: FRI presentation for different scenarios - city scale

The figure above presents the FRI evaluation results for the Nice case study. The evaluation is done for city scale using FRI matrix with 91 indicators. Graph on the left side presents the FRI for BAU and scenario S4. For these scenarios the measures are not considered. The graph on the rights includes the FRI for S1, S2 and S3 scenarios. The measures considered for these two scenarios are flood preparedness, knowledge based and contingency measures respectively.

It can be concluded that implemented measures in S, S2 and S3 scenarios have an influence on FRI. A sharp increase of FRI is for the S3 scenario where the focus is on contingency measures. The increase compared to BAU as a baseline scenario is 18.84%. This high decrease is due to improvement of crisis management for considered events, people mobility and rescue services.

In general, the implementation of measures improves the FRI for considered case study. The level of improvement is in this case measured with developed method for FRI.

Taipei

Because of there have lack of information to be analyzed in Taipei case, only apply the FRI on city scale and not compared with other scales. It is difficult to know how the effect of result in other scales. The four scenarios were chosen and analyzed for the city scale, Baseline and A1B have no measures; Adaptation 1 and Adaptation 2 have mitigation measures. In general, the implementation of the mitigation measures on the scenarios improves the FRI value.

Overall of the FRIs for each scenario on city scale is medium and has subtle change. The results of all scenarios of the overall FRI, A1B scenario has the lowest FRI value is 3.02;the FRI of Baseline is 3.05; Adaptation is 3.32; and Adaptation 2’s FRI value is 3.40.However, the Baseline also hasn’t considered measures either, but the flood hazard of A1B is seriously than Baseline. It should be noted if no measures to reduce or adapt the flood happened that scenario might not be as flood resilient, should more pay attention to them.

From the dimensions point of view, the economic dimension is the lowest whatever under each scenario because the insurance is difficult to performed and the lack of information in Taiwan. But in other dimensions, the value of FRIs are higher than 3. Adaptation 2 presents the best value (4.18) for the physical dimension (Baseline, A1B and Adaptation 1 got the value of 3.06, 2.94 and 3.79 respectively), thus the shelters and retention are considered to be increased and other indicators of measures will reduce vulnerability in this scenario.

This is depend on the management select different plans, scenario even return period to determine the effect by flood since the FRI at a different scale can significantly reflect the flood resilience in urban area. If the implementation of a set of measures, this is important to improve economic dimension in Taipei case.

2 SWOT ANALYSIS

After conducted in depth analysis of flood risk in case study area the SWOT analysis can be performed in order to mark: (i) strengths, (ii) weakness, (iii) opportunities, and (iv) threats.

The SWOT analysis is conducted based on flood risk management frameworks, analyzed measures for implementation. Based on that, the outcome will be recommendations for the future decision makers in flood risk management and toward increase of flood resilience in urban areas.

The outcome of the SWOT analysis is presented below:

Strengths

- Developed local knowledge on water resources, existing flooding processes
- Strong expert knowledge on flooding
- Mostly on the local level the decision making is possible
- Extensive Institutional Infrastructure

Weaknesses

- Lack of civil education especially in European case studies
- Lack of risk information data
- Lack of data sharing regarding known flood risks
- Flood risks caused by episodes of heavy rain (Barcelona, Nice)
- Flood risk with long durations (case studies in monsoon belt)
- Focus only on structural measures
- Disconnection between policy-practice
- Focus on response and relief

Opportunities

- Implementation of the measures defined in the Water Framework Directive.
    - Compliance with environmental objectives
    - Promoting active participation of all stakeholders in the implementation of this Water Framework Directive
- Possibility to learn from international projects

Threats

- Lack of financial resources investments in infrastructure due to economic crisis (upgrading of wastewater treatment plants, rehabilitation of pipelines etc)
- Huge cost for implementation
- No application of Spatial or Urban Planning to prevent urbanization

The adaptation and mitigation measures are analyzed within case studies. The SWOT analysis is carried out in further detail along the measures considered in study and some cross cutting issues.
The following measures are considered within CORFU case studies:

1. Restoration of watercourses (ponds, flood plain restoration, controlled conveyance)
2. Land use control (spatial planning, building regulations, contingency planning and infrastructure)
3. Financial preparedness
4. Capacity building of stakeholders
5. Deployment of flood resilient technology
6. Contingency measures
7. Evacuation and rescue plans

The presented measures are evaluated within FRI assessment and the following SWOT elements are drawn.

1. Restoration of watercourses (ponds, flood plain restoration, controlled conveyance)

S - Avoid flood totally or possible huge reduction of flood wave.

W - Spatial extend of area needed d for this measure is usually valuable for urban planners.

O - This area space can be multifunctional, recreational for example.

T - In the case of maintenance absence health issues are possible.

2. Land use control (spatial planning, building regulations, contingency planning and infrastructure)

S - Direct influence on runoff. Reduction of direct flood damages due to the existing building protection.

W - Institutional framework is needed and with that possible long time for implementation.

O - Recovery time is shorter due to the already implemented measures.

T - Standing costs of implementation has to be taken into account.

3. Financial preparedness

S - Contributing to the fast response

W - Need institutional support on national, regional and municipal level, financial resources needed.

O - Can cover a whole flooded area.

T - Unless effective institutional systems are in, allocation of adequate budget for disaster risk mitigation may be counter-productive as it may not be gainfully utilized.

4. Capacity building of stakeholders

S - Availability of adequate funds for undertaking disaster management and disaster risk reduction.

W - Lack of a common strategic vision and action plan at national and state level. Not clear standards or systematic assessments of training needs or effectiveness of training. The only criterion for assessment is usually the number of people trained.

O - Engaging the networks of civil society organizations working on flood risk management and issues in flood prone areas in training and capacity building efforts.

T - Unless the training is located within the larger vision and approach that is framing the development related to flood risk reduction and increasing flood resilience it can be an ad-hoc activity undertaken simply because there is a given mandate and money available.

5. Deployment of flood resilient technology

S - Effective flood preparedness on building level.

W - Demands financial resources and both legal framework and decisions on individual level.

O - Influencing local economy.

T - Unless there is a support and technical assistance it will stay as an ad-hoc activity and will not desired effect.

6. Contingency measures

S - Very fast results.

W - Detail coordination needed as well as financial resources.

O - Can provide assistance to all.

T - If there is no investment in the training of staff and investment in providing the support during and after flood the effectiveness is low.

7. Evacuation and rescue plans

S - Very fast evacuation, saving life.

W - Detail coordination needed, trainings as well as financial resources.

O - If well coordinated, can provide assistance to all.

T - Unless the evacuation staff is trained and information regarding existing evacuation routes is shared to the population the measure will not have an influence.

8. Forecasting and warning services

S - Contribution to the flood preparedness.

W - Detail coordination needed, effective forecasting system as well as financial resources

O - Be able to prepare population and protect assets before flood.

T - If there is no institutional and financial support the false sense of protection is present which can cause the huge flood damages.

3 CONCLUSION

The objective of WP4 was to elaborate and develop new concepts that could used in order to enrich and improve the flood management strategies in urban environments. The application of the developed methods and tools on various case studies located in Asian and in Europe was used as a validation exercise that has successfully demonstrated the universality of the developed concepts. One of the major challenges for WP4 was to address the complexity of urban environments and to integrate such complexity in a new methodology able to generate efficient flood management strategy. The starting point of the approach is based on the definition of a city and how it has to be defined on a conceptual point of view in order to fit with the purpose of defining a flood management strategy. Many options were available and the chosen option uses the functional analysis that is commonly used in system analysis. In order to analyze the complexity of urban systems, the functional analysis is be used to describe the structure of the city as well as the implementation of measures. The main interest in this approach is to provide indicators that could be used to characterize urban resilience regarding flooding issues.

The objective was to develop and promote a new approach regarding the flood management strategy development and to validate the approach through the various case studies. 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 Flood Risk Management (FRM) frameworks are under the umbrella of the EU Flood Directive (2000/60/EC). The flood risk management in Asian countries is under the disaster risk management planning frameworks.

The diversity of observed situations requested the development of a methodology allowing to assess each defined strategy and to evaluate the efficiency of the associated measures/actions. The chosen approach is based on the maturity level concept. As presented within Step 1 of this report the concept is being utilized increasingly to map out logical ways to improve anorganization’s services. Maturity refers to the degree that an organization consistently carries out processes that are documented, managed, measured, controlled and continuously improved. As presented the method is measuring the level of coordination, integration and implementation of existing frameworks. 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. 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. 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. The developed methodologies for maturity assessment of flood management strategy and flood resilience analysis have been applied at various scales within the different locations in Asia and in Europe.

Based on the evaluation done within Step 1 the new and updated flood risk management plans are defined within Step 2. The plans include measures and strategies that will contribute minimization of flood damages and improve flood resilience in case study areas.

The work developed within WP4 was strongly related to the concept of resilience applied to the context of urban flooding management strategy development.

On the theoretical point of view, resilient urban systems and urban communities should have the ability to accept, resist, recover and learn from damaging events (5R system). The capacity of urban systems and communities is improved in each part of the flood risk management cycle and covers actions related to preparedness, response and recovery. Within the CORFU approach, the five elements of flood risk management are developed: **relief, resist, response, recovery and reflect**.

The different scenarios elaborated regarding the protection level, the urban development and the climate change hypothesis have been integrated in the assessment process and FRI have been produced at the various scale according the priorities identified in each location. This is covered within Step 3. As presented the evaluation is done using developed method for FRI. The application of the developed methodology has been realized at various scales: from parcel to city and for various scenarios taking into account urban development and climate change issues. The application was successful at the various locations and have provided clear added value within the process of flood management strategy development.