EUROPEAN COMMISSION
DIRECTORATE-GENERAL
HUMANITARIAN AID AND CIVIL PROTECTION - ECHO
ECHO A - Strategy, Policy and International Co-operation
Unit A.5 - Civil Protection Policy
Brussels, ECHO.A.5 (2016) 3129102

UD-RASP- Urban Disaster Resilience Through Risk Assessment and Sustainable Planning

Ref. No. ECHO/SUB/2016/740186/PREV19

D4.4 – Future risk scenarios

Coordinated by

IABG mbH Geodaten Factory
Einsteinstraße 20
D-85521 Ottobrunn
GERMANY

In cooperation with:

United Nations University Institute for Environment and Human Security (UNU-EHS)
Platz der Vereinten Nationen 1,
53113 Bonn, Germany

Municipality of Monastir
Avenue Habib Bourguiba,
5019 Monastir, Tunisia

Task	T4	
Action	A4.3	
Dissemination level	✓ Public ○ Restricted to other programme partners (including DG ECHO) ○ Restricted to a group specified by the consortium (including DG ECHO) ○ Confidential, only for members of the consortium (including DG ECHO)	
Publishing date	September 2018	
Task/activity leader	Task: UNU-EHS	Activity: UNU-EHS
Contact person	Michael Hagenlocher (hagenlocher@ehs.unu.edu)	
Contributors	Mostapha Harb, Matthias Garschagen, Felicitas Bellert, Sonia Ayed, Hayet Baccouche, local stakeholders	
Short summary	The aim of this deliverable is to identify possible future risk trajectories using scenario and modelling approaches as a basis for the evaluation of possible adaptation options. A flood model and an urban growth model were developed and applied to simulate urban growth and possible future exposure in Monastir. The outputs were combined with scenarios of societal vulnerability based on narrative storylines developed during participatory scenario workshops with local stakeholders into future risk scenarios, considering urbanization as well as environmental, socioeconomic and political change/transformation processes.	
Keywords	Urban growth, future scenarios, exposure, vulnerability, risk , sub-city scale	

The research leading to these results has received funding from the European Commission Directorate General Humanitarian Aid And Civil Protection (ECHO) under grant agreement No.ECHO/SUB/2016/740186/PREV19.
This publication reflects the views only of the author, and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Table of Contents

List of Figures

Referenced Documents

1. “Flash Flood Modelling in Monastir” – Report for Deliverable 2.2, 3.3 and 4.3
2. “Drivers of vulnerability and risk” – Report for Deliverable 3.1
3. “Multi-hazard risk in Monastir” – Report for Deliverable 3.2
4. “Narrative storylines for future vulnerability trends in Monastir” – Report for Deliverable 4.1
5. “Urban growth model to simulate future urban expansion needs” – Report for Deliverable 4.2
6. “GIS Implementation” – Report for Deliverable 5.1
7. “Web Information System” – Report for Deliverable 5.2
8. “Report on Existing capacities and Stakeholder needs” -– Report for Deliverable 6.1

1 Introduction

This report provides an overview of the development and the main results of the future flash flood risk scenarios which were developed for the city of Monastir for the year 2030 in close collaboration with local stakeholders. The report builds closely on a number of previous deliverables, notably:

- D3.1 "Drivers of risk" which provided the basis for the present-day risk assessment and also for the development of future scenarios,
- D3.2 "Vulnerability and risk assessment (current conditions)" which served as a baseline for the development of future scenarios,
- D4.1 "Narrative storylines of future vulnerability trends in Monastir" which describes a conceptual scenario framework and associated narrative storylines which guided the development of future risk scenarios,
- D2.2 "Flash flood modelling in Monastir" which served as a basis for the future urban exposure simulations,
- D4.2 "Urban growth model to simulate future urban expansion" which served as an input for the future urban exposure simulations

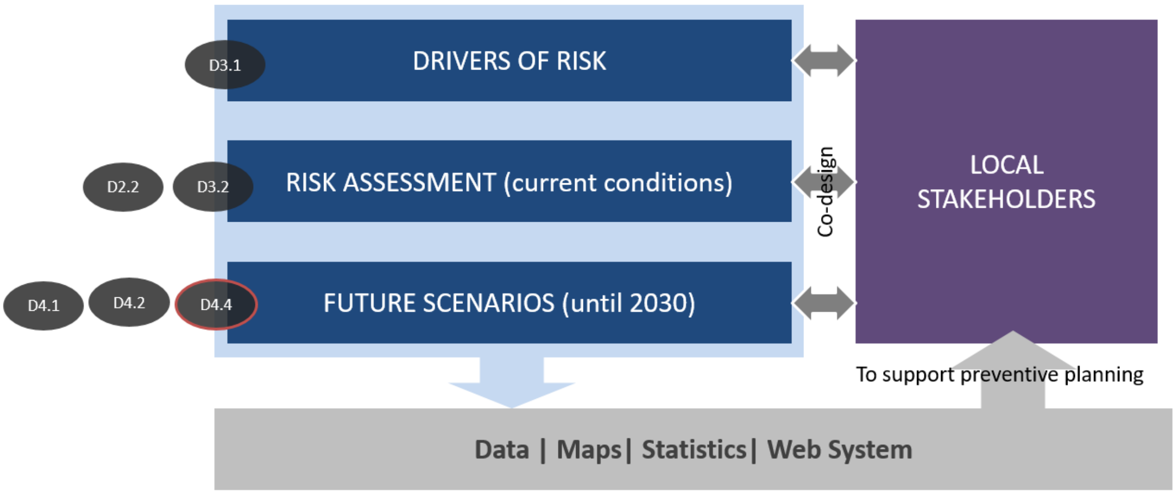


Figure 1: Overview of the risk assessment and scenario development

Drawing on these deliverables (see Figure 1), this report summarizes how the spatial scenarios of future vulnerability were developed at the sub-city scale and integrated into future scenarios of flash flood risk in 2030. The outcomes are provided in the forms of data, maps and reports, but were also integrated into the Web System that was developed within the project (see D5.2).

2 Developing risk scenarios until 2030 at the sub-city scale

2.1 Approach: integrating qualitative and quantitative information

For the development of the scenarios presented here, the project partners attached high value to the participation of relevant local stakeholders under the coordination of the municipality. Therefore, two scenario workshops were organized in Monastir in October 2017 and May 2018, where two axes were defined by local stakeholders that represent key development trends for Monastir along a continuum of (1) economic growth and (2) law enforcement. The created framework led to a four-dimensional scenario space (Figure 2) that was used to develop future exposure, vulnerability and risk scenarios. For further details on the scenario space and the associated narrative storylines see deliverable 4.1.

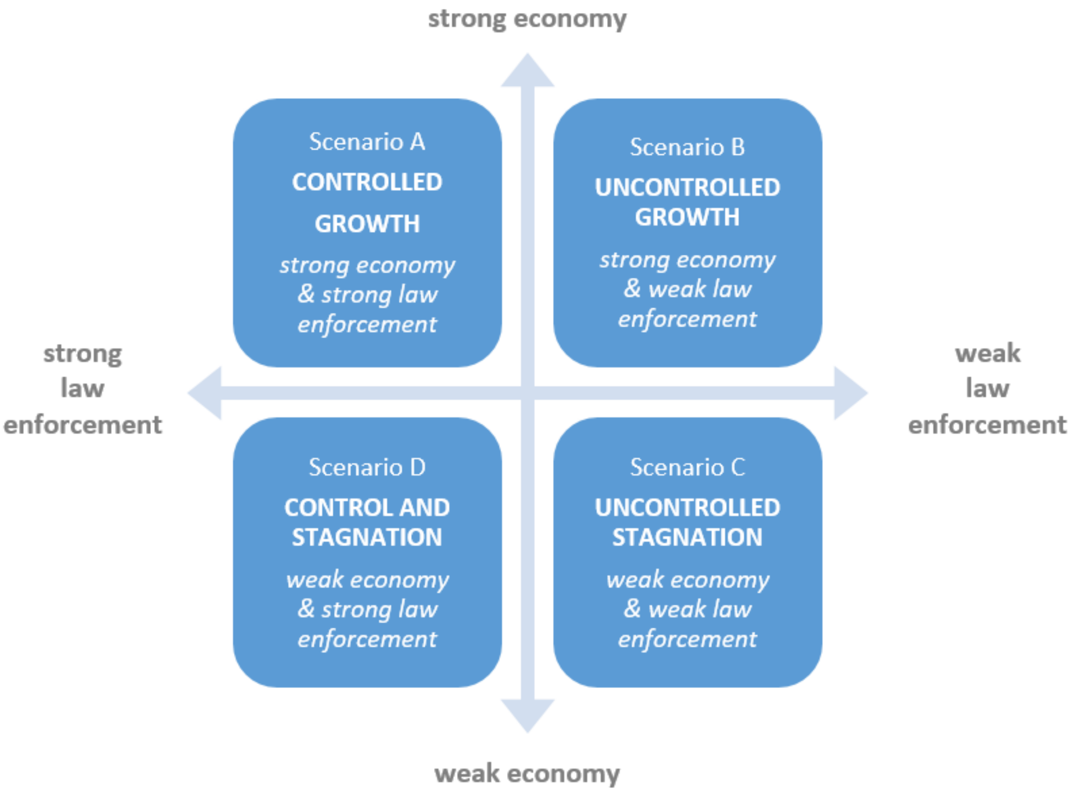


Figure 2: Scenario space developed during the scenario workshops

This highly participatory approach of developing the scenario framework and associated storylines was then complemented by spatial simulation of future urban growth and exposure as well as social vulnerability scenarios until 2030. These were then integrated into spatially explicit scenarios of future flash flood risk at the sub-city scale. Following the scenario framework, both business-as-usual (BaU) projections and four different scenarios (scenario A-D) were developed for exposure, vulnerability and risk.

2.2 Urban growth and exposure scenarios (2030)

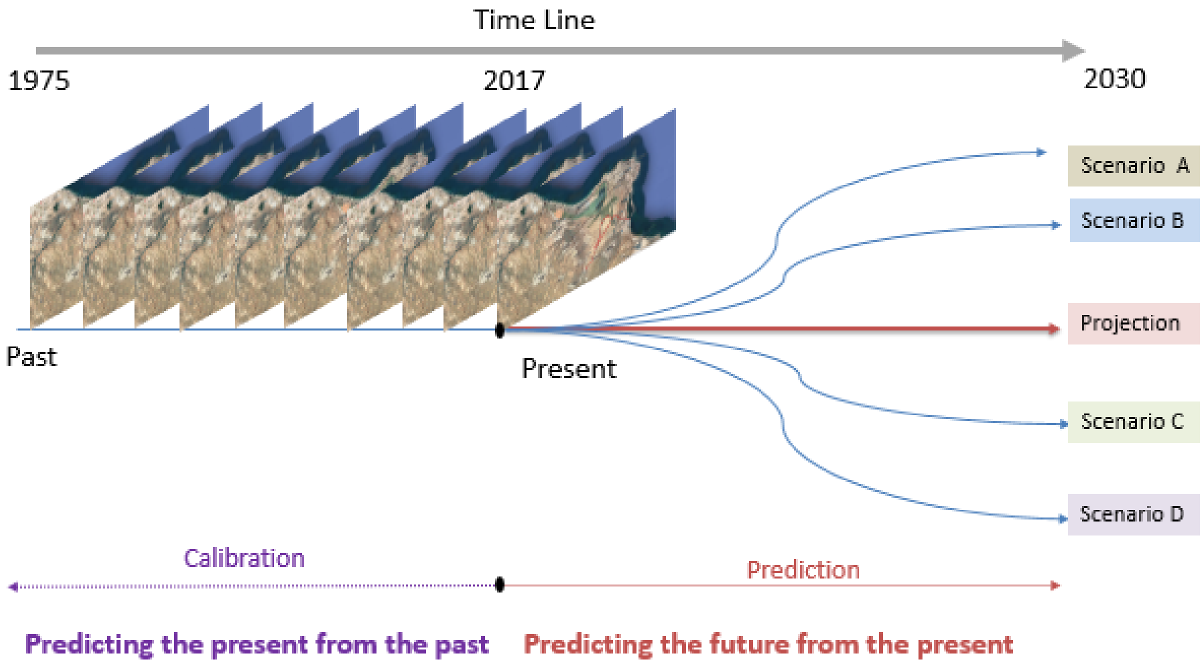


Figure 3: Chart illustrating the overall modelling process of the SLEUTH urban growth simulations

The SLEUTH urban growth model was used to simulate future urban growth until 2030 by integrating the outcomes of the participatory scenario development with quantitative data analysis based on multi-temporal remote sensing data for the period 1975-2017 (see Figure 3). More details on the urban growth simulations are provided in deliverable 4.2.

In order to derive future exposure scenarios, two main inputs were used:

1. The probabilistic simulations of Monastir urban growth until 2030, including a BaU projection and four scenarios (scenario A-D) simulations: BaU, A, B, C, & D. Within this process, and as described in detail in D4.2, only areas with high probability of conversion into urban (over 80%) were considered to estimate the exposure of urban settlements until 2030.

2. A deterministic flash flood hazard map with 100 years return period and inundation levels above 20 cm. The hazard map was used to delineate the areas prone to events with medium to high intensity.

The spatial overlap between the future urban expansion scenarios and the hazard map were used to determine the exposed areas. Then, the ratio of the exposed areas in each sub-unit were used to evaluate the absolute (in hectares) and relative exposure (in %) among the city neighborhoods.

2.3 Future scenarios of social vulnerability and risk to flash floods (2030)

Figure 4 shows the overall workflow for developing future vulnerability scenarios at the sub-city scale.

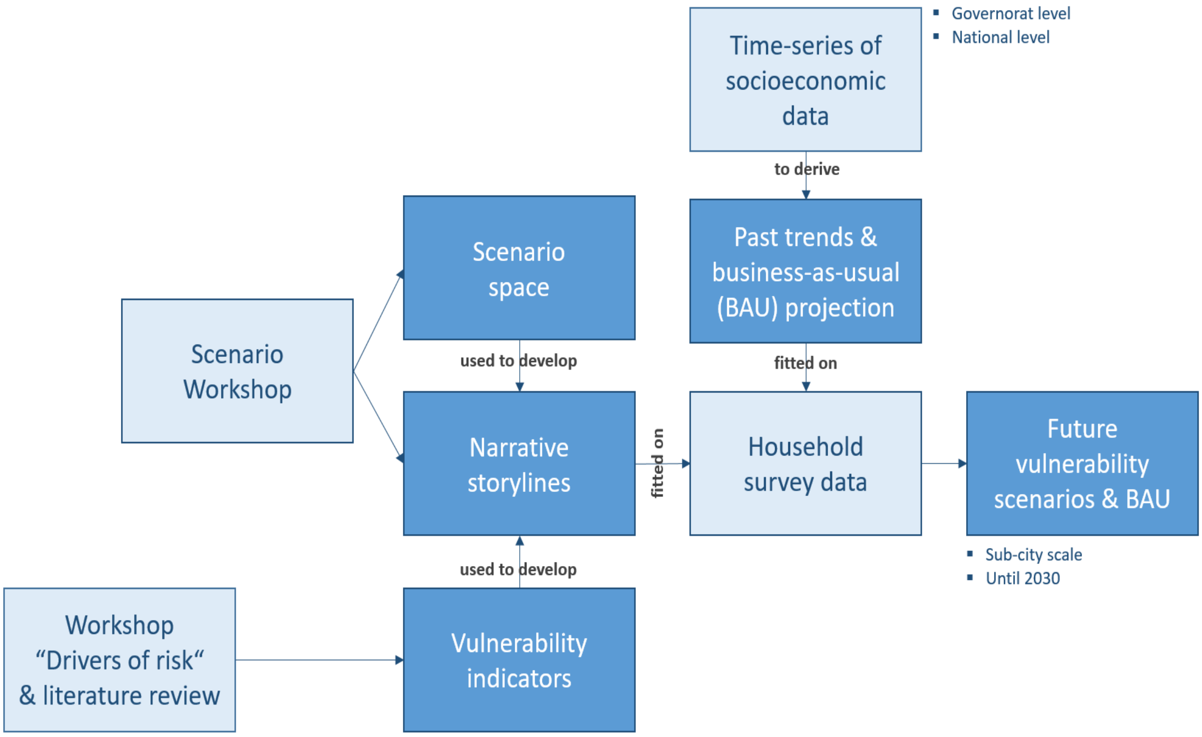


Figure 4: Workflow for the development of vulnerability scenarios at the sub-city scale

Following the development of the narrative storylines of future vulnerability until 2030 for Monastir, the storylines were translated into a set of assumptions for each of the social vulnerability indicators that were used to assess present-day vulnerability and risk to flash floods (see Figure 5).

2.4 Perceived future outlook of the population of Monastir

In addition to the workflow described above, as part of the household survey which was conducted in 15 selected sub-units of the city (see deliverable 3.2 for a description of the household survey), citizens of Monastir were asked on their personal perception of future developments in Monastir until 2030 (i.e. changes in personal income, education level, housing conditions, and infrastructure development).

SOCIAL VULNERABILITY INDICATORS (Flash Floods)		Scenario A – Controlled growth	Scenario B – Uncontrolled growth	Scenario C – Uncontrolled stagnation	Scenario D – Control & stagnation
Susceptibility	Households below national poverty line (%)*	Major reduction in poverty across all income groups	Weak overall reduction in poverty (not homogenous for all income groups)	Increase in poverty across most income groups	Minor increase in poverty across all income groups
	Unemployment rate (%)*	Major reduction in unemployment across all income groups	Weak overall reduction in unemployment (not homogenous for all income groups)	Increase in unemployment across most income groups	Stagnation
	GINI Index	Reduction in inequality	Strong increase in inequality	Business-as-usual trend	Reduced inequality
	Dependency ratio (%)*	Business-as-usual trend			
	Disabled people (%)	Increased spending on health care with positive effects on health conditions	Increased spending on health care with positive effects on health conditions	Decreased spending on health care (stagnation)	Decreased spending on health care (stagnation or decline)
	Illegally built residential houses (%)*	Strong reduction of illegal/informal housing	Sharp increase in illegal/informal housing	Increase in illegal/informal housing	Weak reduction of illegal/informal housing
	Risk perception of population (categorical)	Major improvement in risk perception through training & awareness campaigns	Minor improvement in risk perception through training & awareness campaigns	Business-as-usual trend	Business-as-usual trend
Lack of coping capacity	Number of people trained in crises management per 1,000	Increase in training & equipment (after 2025)	Minor investment in DRR/DRM	No further investments in DRR/DRM (stagnation or decline)	Business-as-usual trend
	Houses with more than one floor (%)	Major increase in number of buildings with > 1 floor	Minor increase in number of buildings with > 1 floor	Business-as-usual trend	Business-as-usual trend
	Households with savings (%)	Major Increase in savings across all income groups	Increase in savings for higher income groups (not for most vulnerable)	Reduction in savings across most income groups	Minor reduction in savings across most income groups
	Households with access to credits / loans (%)	Major increase of number of HHs with access to credits across all income groups	Weak overall increase in access to credits (not homogenous for all income groups)	Decrease in access to credits	Stagnation
	Households receiving remittances (%)	Increase in households receiving domestic remittances	Increase in households receiving domestic & international remittances	No increase in remittances (stagnation or decline)	No increase in remittances (stagnation or decline)
	Households without flood insurance (%)	Major increase in insurance coverage (after 2025)	Weak overall increase in insurance coverage (not homogenous for all income groups) (after 2025)	Stagnation	Weak increase in insurance coverage
	Social network	Business-as-usual trend			
	Households subscribed to government assistance programs	Increasing breadth and depth of social protection programs (after 2025)	Minor investment in social protection programs (after 2025)	Stagnation	Stagnation
Lack of adaptive capacity	Population with post-secondary education (%)*	Increase in population with post-secondary education	Minor increase in population with post-secondary education	Business-as-usual trend	Business-as-usual trend
	Renters (%)*	Increasing number of renters	Minor increase in number of renters (notably high-income)	Business-as-usual trend	Business-as-usual trend
	Local disaster risk management & adaptation plans (yes/no)	Initiation of policies and plans & trust in their implementation	Business-as-usual trend	Business-as-usual trend	Initiation of policies and plans & trust in their implementation

= strong overall positive effect | = weak overall positive effect | = mixed effect | = weak negative effect | = strong negative effect | = business-as-usual trend / neutral

Figure 5: Storylines broken down for each social vulnerability indicator

Next, time-series of socioeconomic data were collected for each of the social vulnerability indicators. Time-series of socioeconomic data covering the past 15 years were analyzed at the governorate (e.g. unemployment rate, dependency ratio, renters, population with post-secondary education) and national level (e.g. poverty, etc.) to derive past trends and create business-as-usual (BaU) projections until 2030. Where possible, triangulation with additional data sources was used to validate the outcomes of the BaU projections: For example, for the indicator *unemployment rate* data from the International Monetary Fund (IMF) World Economic Outlook[1] or for the indicator *dependency ratio* data from the Pardee Center for International Futures (IFS)[2] at the University of Denver was used for triangulation.

In a last step, the identified BaU projections and the four scenarios for each indicator were super-imposed on the household survey data that was also used to inform the assessment of current social vulnerability (see D3.2) in order to derive future scenarios of social vulnerability to flash floods at the sub-city scale. Future risk scenarios were then developed by integrating the outputs of the future exposure and vulnerability scenarios.

[1] https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD/TUN
[2] http://www.ifs.du.edu/ifs/frm_CountryProfile.aspx?Country=TN

3 Results

The results of the urban growth and exposure simulations show that according to the BaU scenario, the city is likely to grow by additional 127 ha by 2030 (8.1% growth). Moreover, with differences across scenarios, the highest urban expansion is expected in Scenario B (149 ha, uncontrolled growth), for further details see D4.2. The future exposure in 2030, for the surveyed units, show that the relative increase in the exposure to flash floods will be pretty close among the alternative scenarios. However, the BaU scenario appeared to have the highest expected exposure followed by Scenarios A, D, B, and C respectively.

Table 1: The relative increase of flash flood exposure in the surveyed units by 2030

Scenarios	Exposure Increase (%)
BaU	1.65
A	1.61
B	1.58
C	1.57
D	1.59

Figure 6 shows the outcomes of the BaU projection and the four social vulnerability scenarios in 2030 for the surveyed sub-units in Monastir. Index scores vary between zero and one [0-1], where a score of zero reflects no vulnerability and a score of one would reflect extremely high vulnerability.

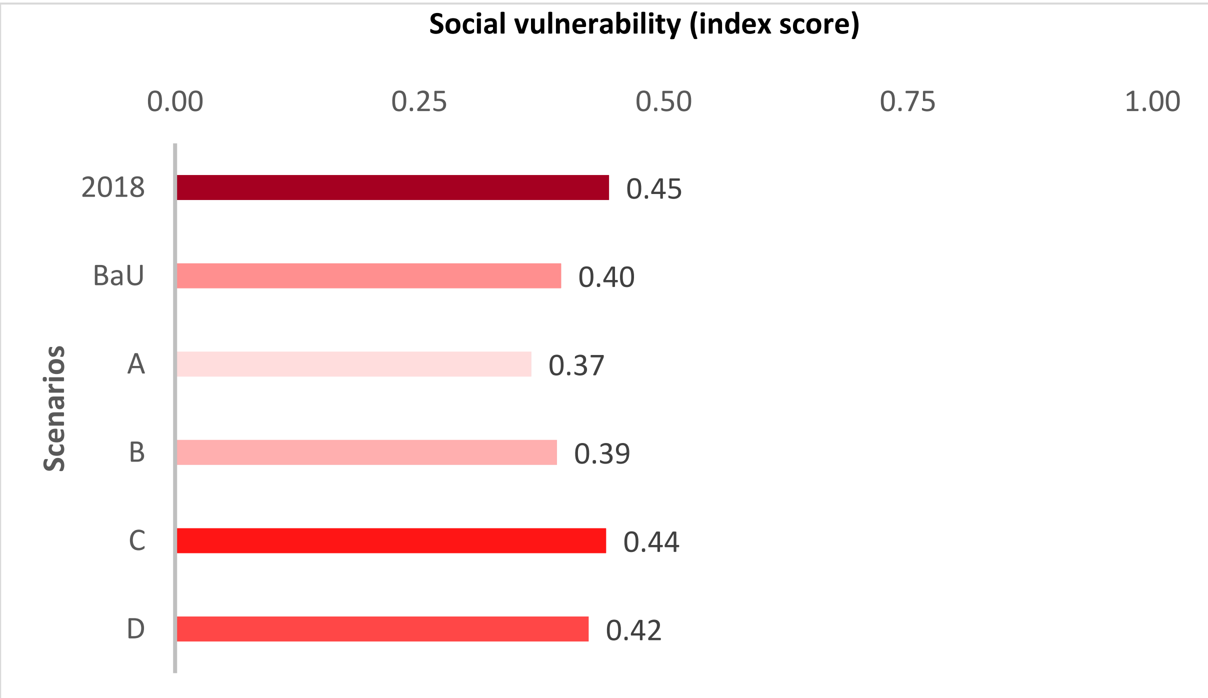


Figure 6: Future vulnerability scenarios (2030) for the surveyed sub-units in Monastir

According to all simulations it is likely that there will be a reduction from the current level of social vulnerability (0.45 in a scale from zero to one) by 2030, yet to different degrees. The outputs of the vulnerability scenarios show that the largest reduction in social vulnerability is expected in Scenario A (controlled growth), while the smallest reduction is expected in Scenario C (uncontrolled stagnation).

Figure 7 demonstrates the outcomes of the BaU projection and the future risk scenarios in 2030 for Monastir. Index scores vary between zero and one [0-1], where a score of zero reflects no risk and a score of one reflects extremely high risk.

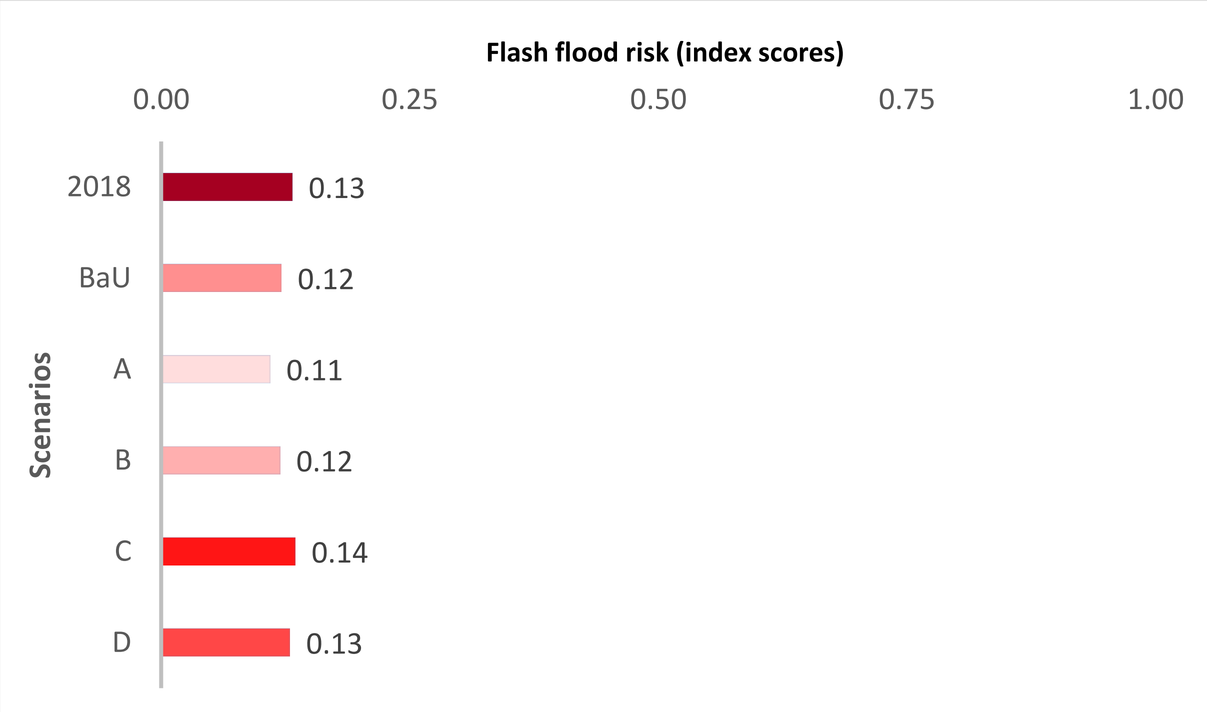
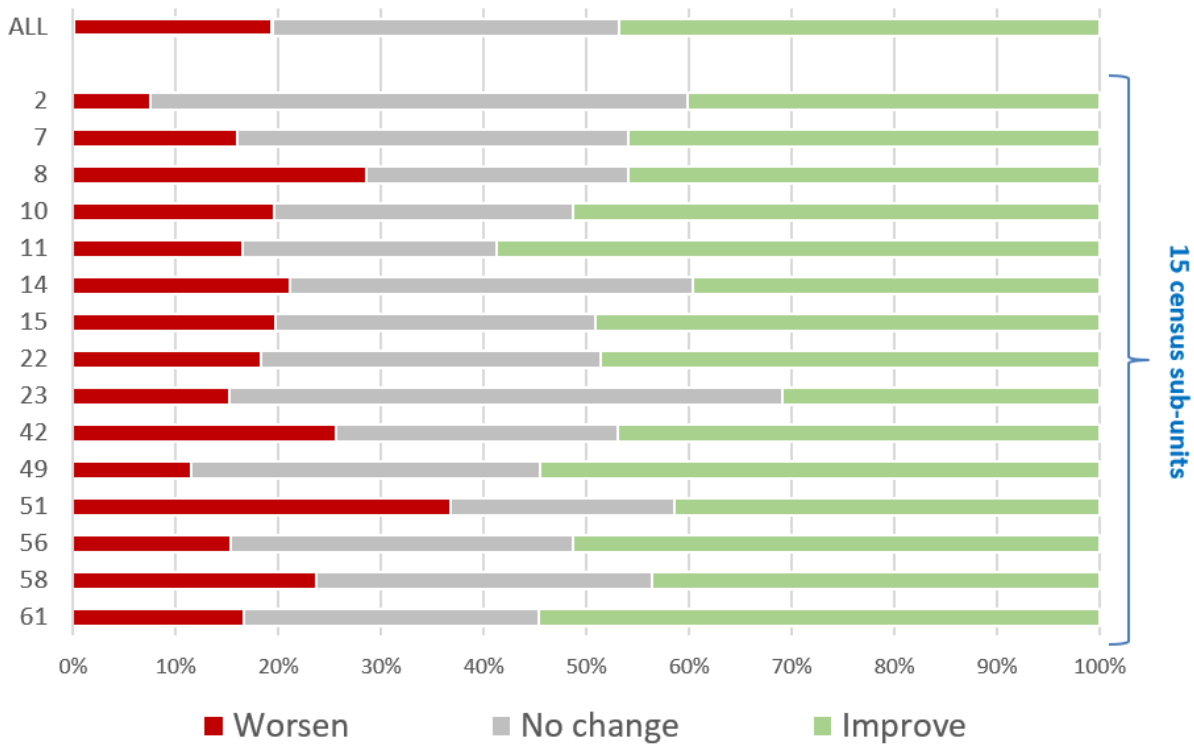


Figure 7: Future flash flood risk scenarios (2030) for surveyed sub-units in Monastir

Figure 7 clearly shows that there is only a minor change in flash flood risk across the four alternative scenarios and the BaU projection. While flash flood risk is expected to decrease most in Scenario A (controlled growth), it will slightly increase in Scenario C (uncontrolled stagnation) or stay the same (Scenario D). However, due to existing uncertainties in the data and the scenario development process, these differences have to be interpreted with care.

Finally, the risk perception of the households on the expected future changes of Monastir was assessed. Figure 8 shows the results of the household survey where citizens were asked on their perceived future outlook for 2030. The figure clearly shows that overall, the interviewed households are rather positive in regards to the future (e.g. regarding household income, education levels, but also infrastructure development in the city). However, the survey has also showed that household members living in sub-unit 51 are more concerned regarding the future compared to the households in other sub-units. According to the household survey, sub-unit 51 is also characterized by very high unemployment (41% of all households), a low number of households with savings (13%) and low education levels which might add to the overall negative perception of the future.



* represents the average of respondent's opinion on future conditions of the following elements: personal income, education level, house conditions, conditions of city's sewage, drainage and waste collection's networks

Figure 8: Perceived future outlook of the population of Monastir (2030)

4 Conclusions

Urban areas and future exposure will expand in the different scenarios from the current state, with the highest expected increase in the BaU projection followed by Scenarios A, D, B, and C respectively. Social vulnerability and risk will decrease almost in all scenarios, the lowest vulnerability and risk in Scenario A (controlled growth) and the highest vulnerability and risk in Scenario C (uncontrolled stagnation).

The main limitation faced in the scenarios creation was the availability of socioeconomic data in terms of reliable, updated time-series of high-resolution (i.e. sub-city scale) census data. Thus, the conducted risk scenarios were restricted to a set of representative sub-units of the city covered by the household survey.