

Cities and Climate Change - Resilience Modelling

Slobodan P. Simonović

Department of Civil and Environmental Engineering
Western University



2 | CONCLUSIONS

- There are practical links between climate change adaptation, disaster risk management, and sustainable development leading to:
 - reduction of disaster risk and re-enforcing **resilience** as a new development paradigm
- **Systems approach** to quantification of resilience allows:
 - capturing temporal and spatial dynamics of climate change adaptation
 - better understanding of factors contributing to resilience
 - more systematic assessment of various measures to increase resilience
- Understanding of **local context** of vulnerability and exposure is fundamental for increasing resilience

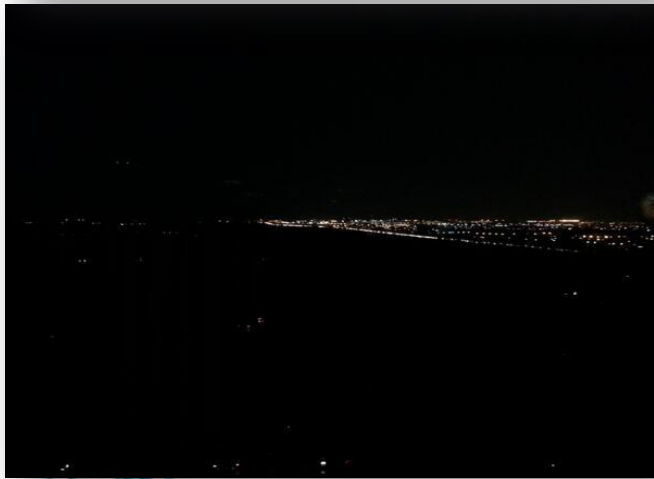




- Bow River
 - Peak flow 2,400 m³/sec
 - 8 x the regular flow
 - 3 x 2005 flood
- Elbow River
 - Peak flow 1,240 m³/sec
 - 12 x the regular flow
 - 3 x 2005 flood
- Outflow below Glenmore dam
 - 700 m³/sec
 - 7 x the normal
 - 2.5 x 2005 flood
- 26 communities evacuated
- 100,000 people affected
- 20 bridges closed
- 34,000 people without power

4 | TORONTO

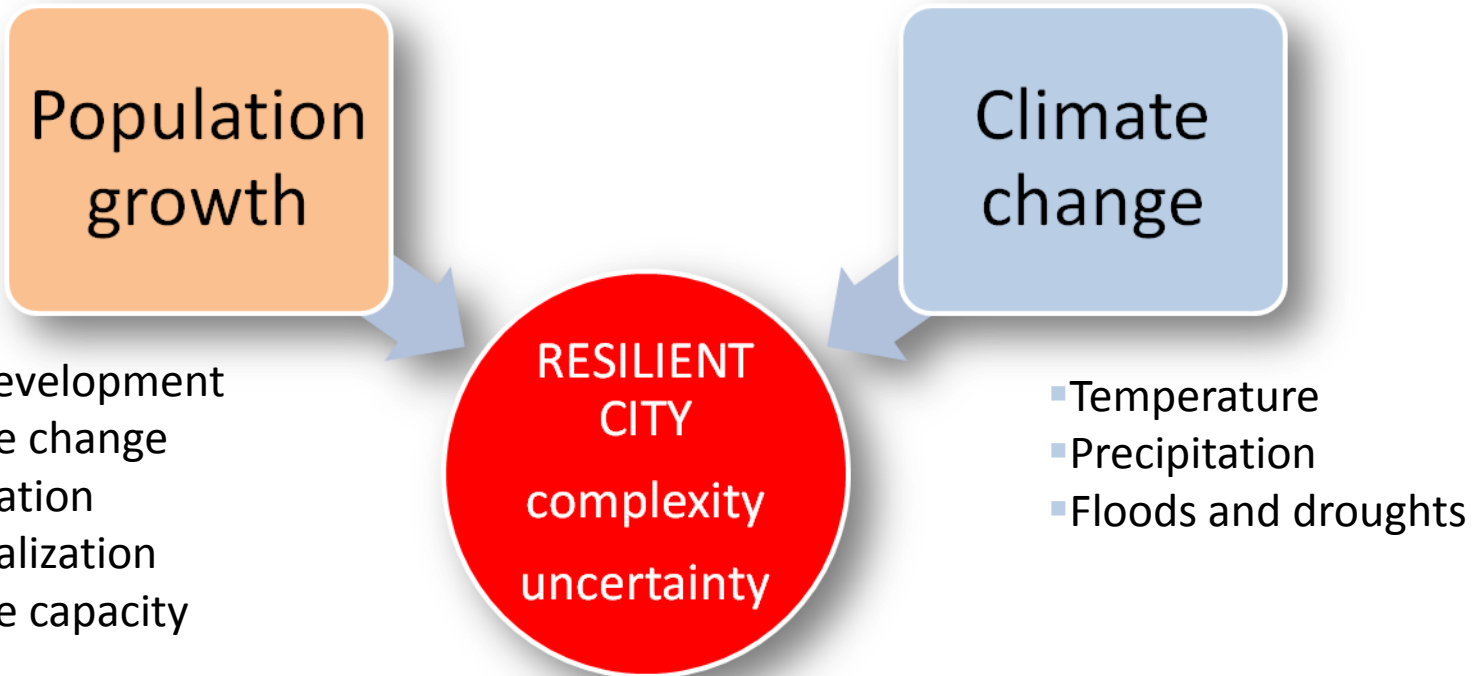
July 2013



- Rain storm
 - 126 mm in two hours (74.4 mm July average)
- At least 300,000 people affected
- 1,400 train passengers stranded for hours
- More than 300,000 people without power
- Major traffic arteries flooded
- Insured damage \$850 M
 - 2005 storm \$671 M
 - 2009 storm \$228 M

5 | INTRODUCTION

Setting the stage



- Rapid development
- Land use change
- Urbanization
- Industrialization
- Adaptive capacity

- Temperature
- Precipitation
- Floods and droughts

- Systems approach
- Resilience modelling

6 | INTRODUCTION

Project

- Project: Coastal Cities at Risk (CCaR)
 - Building Adaptive Capacity for Managing Climate Change in Coastal Megacities
 - International research initiative on adaptation to climate change
 - International Development Research Centre - NSERC, SSHRC, CIHR
 - Five years - \$2.5 M
 - Vancouver – Canada
 - Manila – Philippines
 - Lagos – Nigeria
 - Bangkok - Thailand



Manila



Bangkok

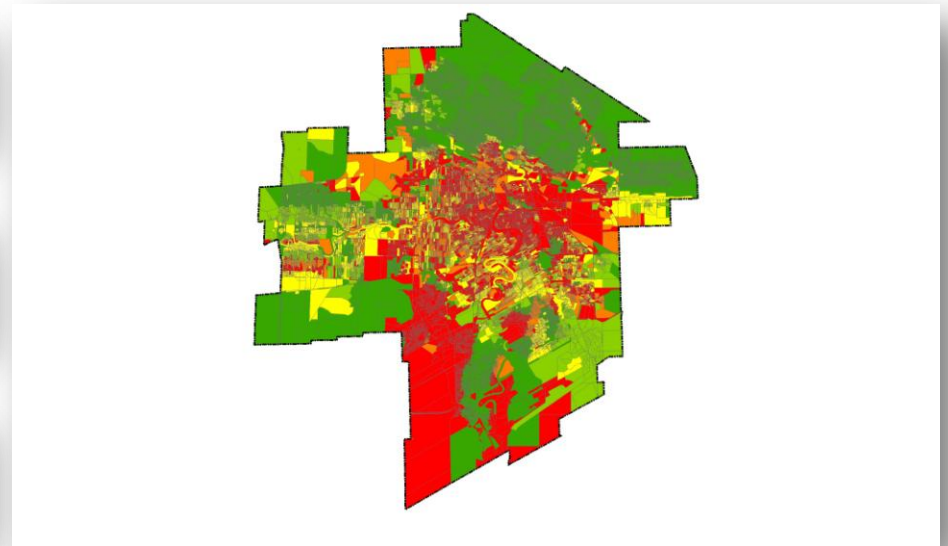
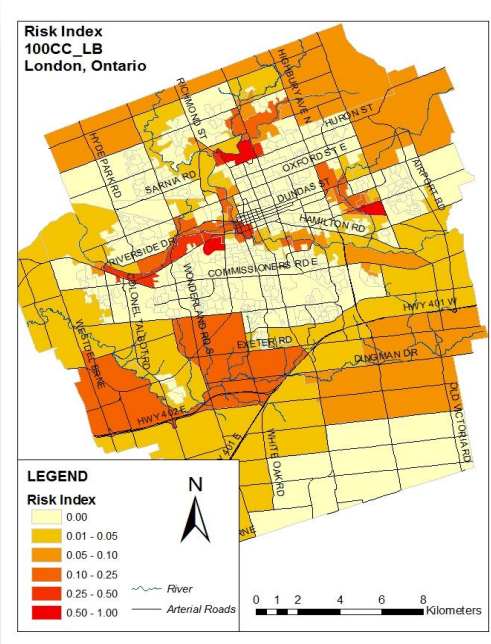


Lagos



- Vancouver – Canada (OECD rating)
 - 16th for exposed assets – USD \$55 billion at risk
 - 32nd in terms of population at risk – 320,000 people exposed

- Embrace the broad definition of risk
 - Risk = Hazard x Consequence**
- Consider paradigm change
 - Risk -> Resilience**



9 | MODELING RESILIENCE

Basics

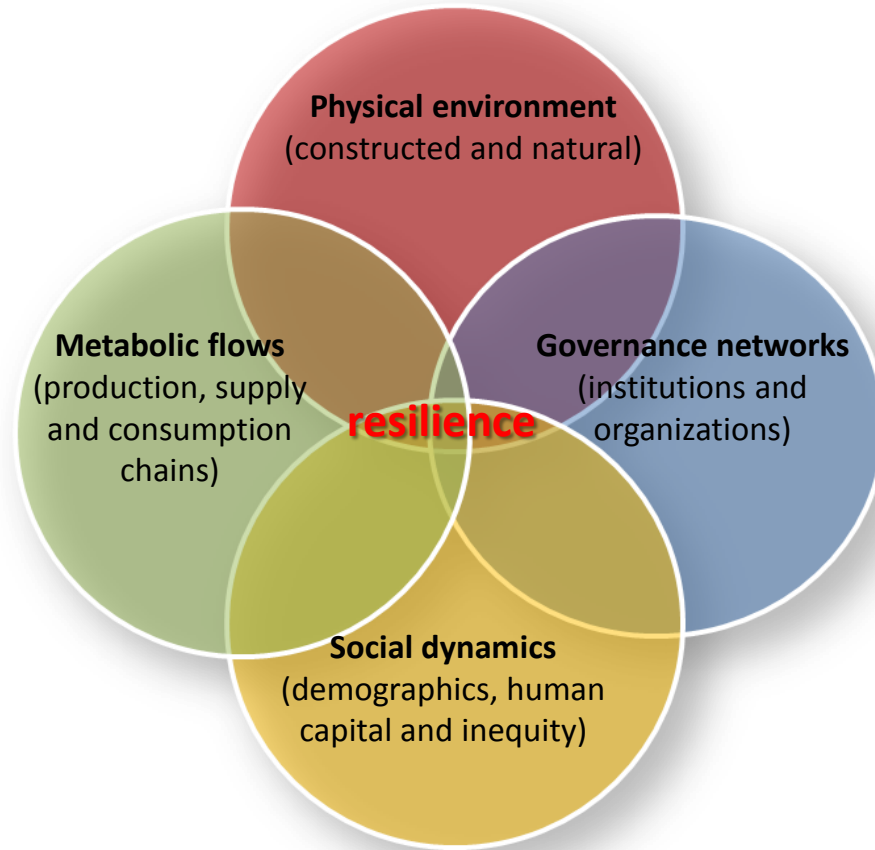
- Broader concept of resilience
 - The ability of the system to reduce the chance of shock, to absorb a shock if it occurs and to recover quickly after a shock
- Resilient system is one that
 - Reduces failure probability
 - Reduces consequences from failures in terms of live lost, damage, and negative economic and social consequences
 - Reduces time to recovery (restoration of a specific system or set of systems to their 'normal' level of performance)
- Resilient city
 - A resilient city is a sustainable network of physical (constructed and natural) systems and human communities (social and institutional) .



Toronto , Fricke Friday, August 25, 2005

10 | MODELING RESILIENCE

Basics



Modified after Resilience Alliance, 2012 (www.resalliance.org)

11 | MODELING RESILIENCE

Space-time dynamic resilience measure (ST-DRM)



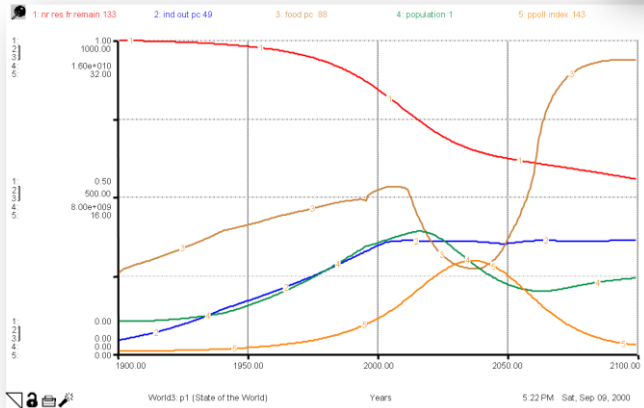
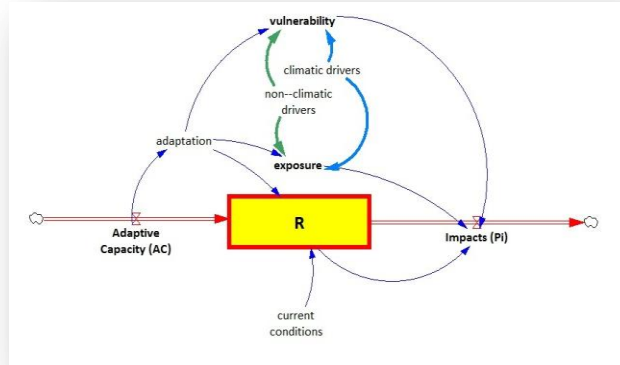
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- Dimensions of resilience (t, s)
 - Time
 - Space
- Units of resilience - SP
 - Physical
 - Health
 - Economic
 - Organizational
 - Social
 -
- Properties of resilience (physical and social systems) – AC
 - Robustness
 - Redundancy
 - Resourcefulness
 - Rapidity
- **System performance**
- **System adaptive capacity**



12 | MODELING RESILIENCE

Implementation - resilience simulator



Temporal dynamics

SD \longleftrightarrow GIS
dynamic data exchange



Spatial dynamics

13 | MODELING RESILIENCE

Implementation - resilience simulator

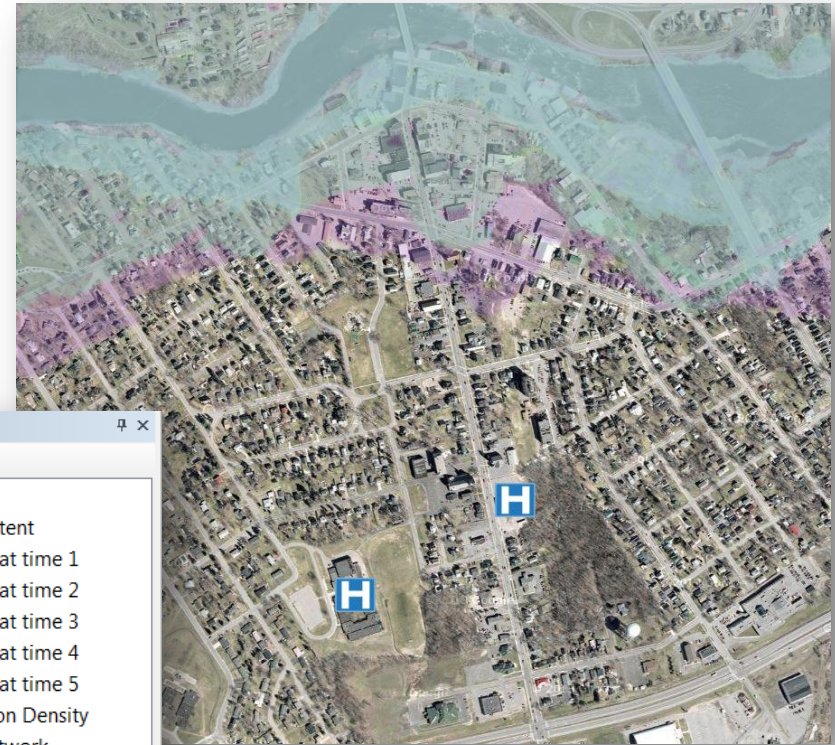
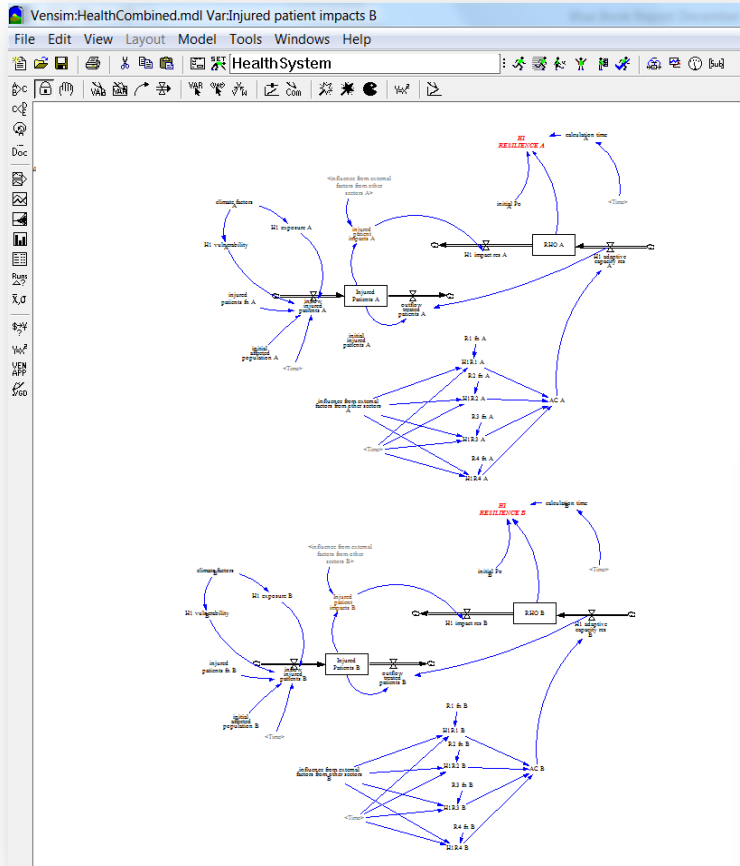
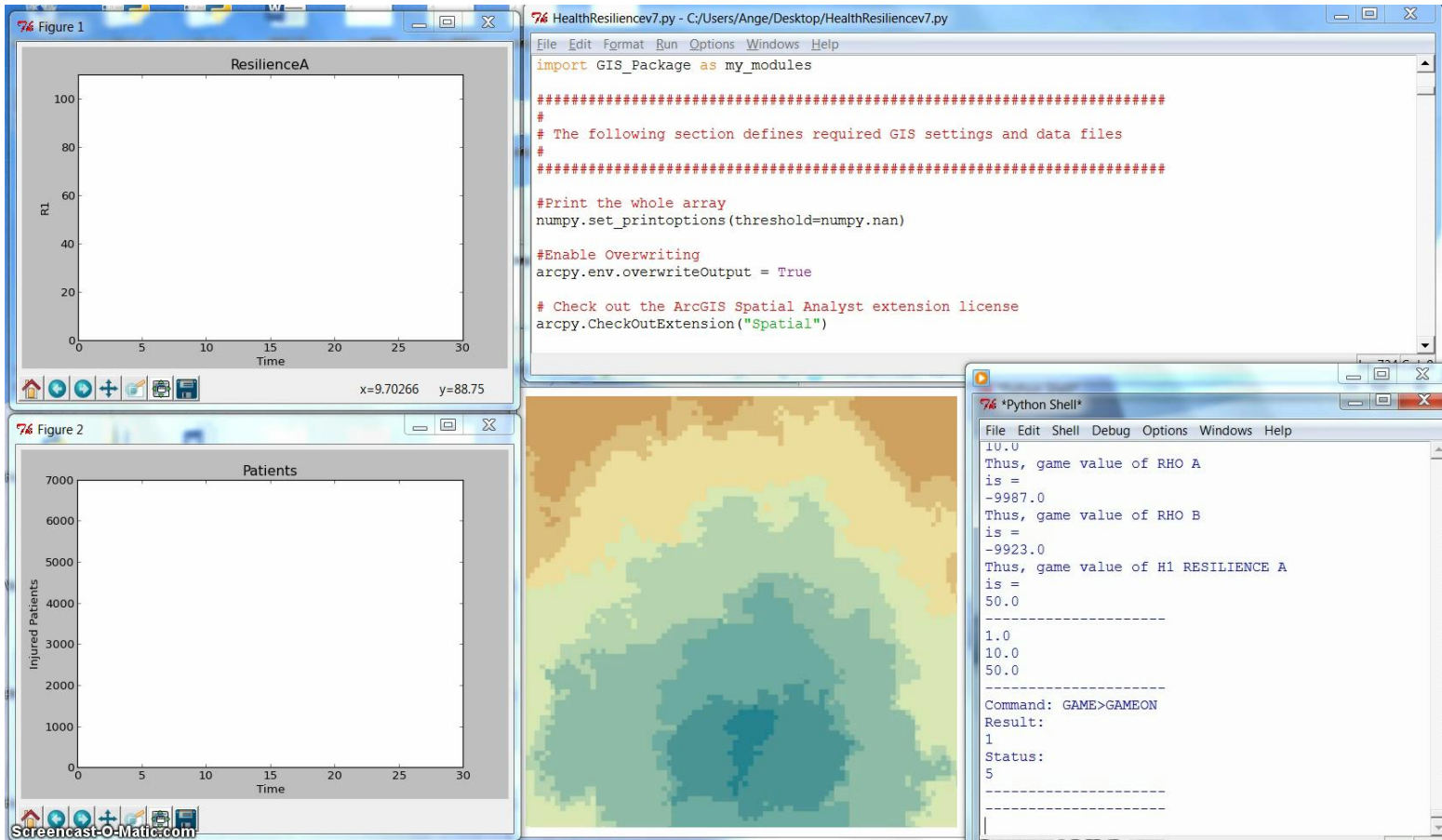


Table Of Contents

- Layers
 - Water Extent
 - flood at time 1
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 - flood at time 3
 - flood at time 4
 - flood at time 5
 - Population Density
 - Road Network
 - Hospital Locations
 - Hospital Service Areas

14 | MODELING RESILIENCE

Implementation - resilience simulator



The screenshot displays a Python script named `HealthResiliencev7.py` and its execution results. The script is located at `C:/Users/Angel/Desktop/HealthResiliencev7.py`. It includes comments and code for importing GIS packages, setting print options, enabling overwriting, and checking out the ArcGIS Spatial Analyst extension license.

```
File Edit Format Run Options Windows Help
import GIS_Package as my_modules

#####
#
# The following section defines required GIS settings and data files
#
#####

#Print the whole array
numpy.set_printoptions(threshold=numpy.nan)

#Enable Overwriting
arcpy.env.overwriteOutput = True

# Check out the ArcGIS Spatial Analyst extension license
arcpy.CheckOutExtension("Spatial")
```

The execution results in the Python Shell window show the following output:

```
File Edit Shell Debug Options Windows Help
10.0
Thus, game value of RHO A
is =
-9987.0
Thus, game value of RHO B
is =
-9923.0
Thus, game value of H1 RESILIENCE A
is =
50.0
-----
1.0
10.0
50.0
-----
Command: GAME>GAMEON
Result:
1
Status:
5
-----
```

Figure 1: ResilienceA plot showing Resilience (R) on the y-axis (0 to 100) versus Time on the x-axis (0 to 30). The plot is currently empty.

Figure 2: Patients plot showing Injured Patients on the y-axis (0 to 7000) versus Time on the x-axis (0 to 30). The plot is currently empty.

A spatial plot shows a heatmap of the simulation area, with colors ranging from yellow (high values) to dark blue (low values).

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www.slobodansimonovic.com

Research -> FIDS -> Research projects

- Simonovic, S.P., and A. Peck, (2013) "Dynamic Resilience to Climate Change Caused Natural Disasters in Coastal Megacities - Quantification Framework", *British Journal of Environment and Climate Change*, 3(3): 378-401.

