Introducing the model for the project

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SEN1211

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What will I talk about

Your project for this course!

1. What is the background / why it is meaningful
2. The project and model that you will work with
3. What I did with that model

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Background

Why we do this

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‘Off-the-charts records’ Has humanity finally broken the climate?

Extreme weather is ‘smacking us in the face’ with worse to come, but a ‘tiny window’ of hope remains, say leading climate scientists

Climate crisis Dramatic action needed to curtail ‘crazy’ extreme weather

China’s summer of climate destruction

1 day ago

Climate change

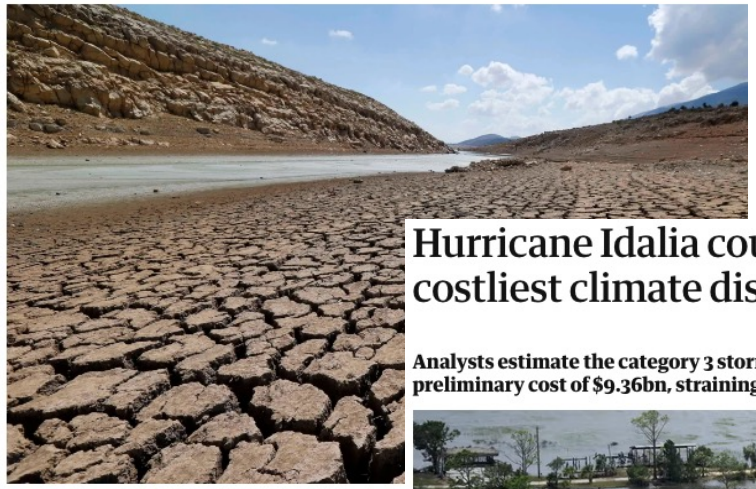
Swathes of the Zhuozhou corn in north China have been wiped out

By Stephen McDonell
China correspondent

China's summer this year has seen both extreme heat and devastating floods.

A quarter of humanity faces extreme water stress – and it’s poised to get worse, new report finds

By Hafsa Khalil, CNN
Updated 5:06 AM EDT, Wed August 16, 2023



The dried cracked bed of the Qaraoun lake in West Bekaa, Lebanon on September 19,

(CNN) — The world is facing an “unprecedented water crisis” crisis, according to a new report.

The Washington Post
Democracy Dies in Darkness

CLIMATE >
Expanded coverage of a changing planet

(AP)

What Arctic ice tells us about climate change
By Sarah Kaplan • 1 hour ago

The Montana climate kids’ lawsuit has energized activists, including this one
By Kate Selig

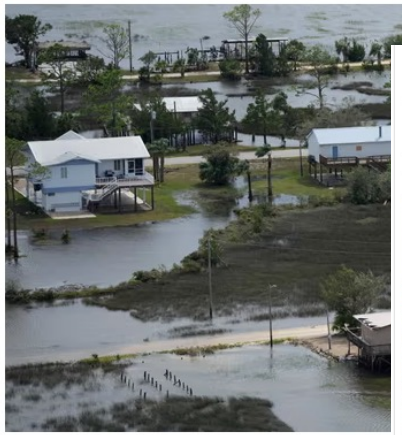
No, recycling is not a big factor in fighting climate change. What works is different from what people think.
By Kate Selig and Emily Guskin

Look up your city to learn whether heat will be dangerous in the coming days
By Naema Ahmed and John Muyskens

Hurricane Idalia could become 2023’s costliest climate disaster for the US

Analysts estimate the category 3 storm has already racked up a preliminary cost of $9.36bn, straining the insurance industry

The Guardian



Receding storm waters surround homes in Keaton E Idalia. Photograph: Rebecca Blackwell/AP

‘Smashed’: summer of 2023 the hottest ever recorded

The climate crisis and emerging El Niño event pushed up temperatures and drove extreme weather across the world

Scorched sunflowers in a field during a heatwave in the village of Puy-Saint-Martin, south-east France, in August. Photograph: Jeff Pachoud/AFP/Getty

The summer of 2023 was the hottest ever recorded, as the climate crisis and

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Climate change impacts are seen all over the world

Not adapting costs a lot – both money and lives

→ There is a need to adapt

How do we best adapt?

The project

Introduction to the project and minimal model

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The project

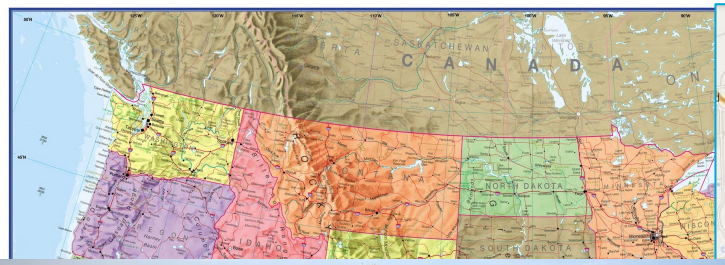
Main Idea:

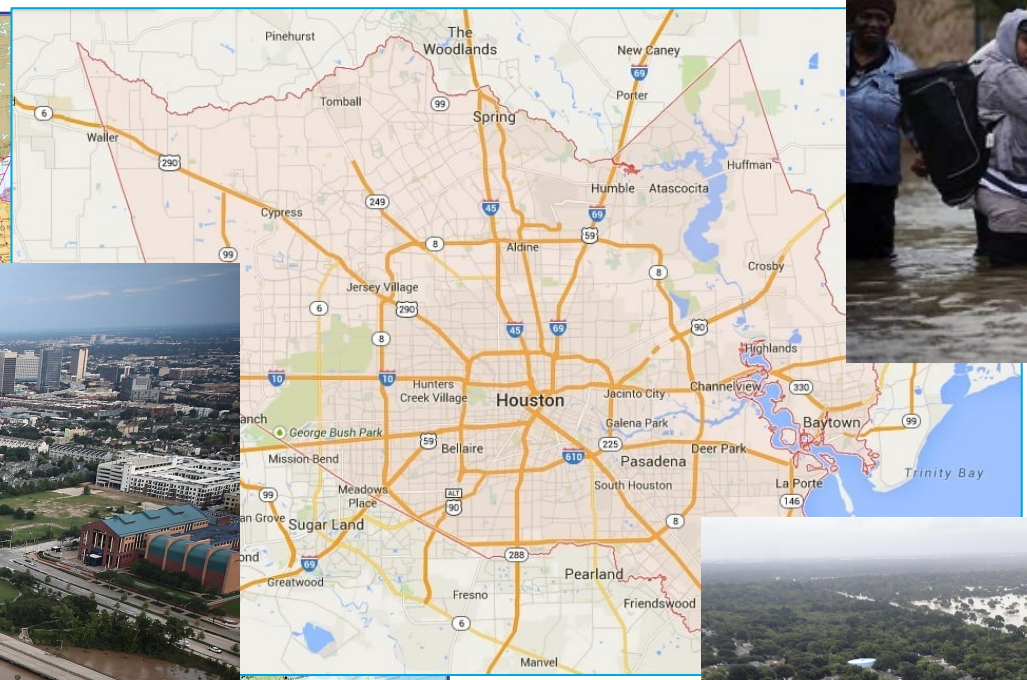
- Model climate change adaptation across different scales and interaction across the scales

	Scale of Climate Change Adaptation
Macro	**Governments**
Meso	**Communities**
Micro	**Individuals / Households**

Households ⟷ Communities ⟷ Governments

Case study – Harris county





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Household agent

- Takes adaptation measures to protect itself against flooding
- Interacts with other households to exchange information

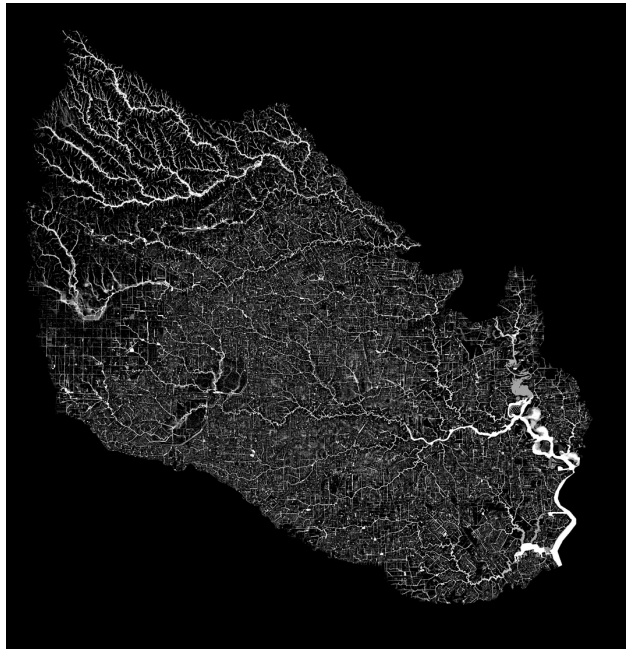
- Gets hit by flooding and experiences damage

Government agent

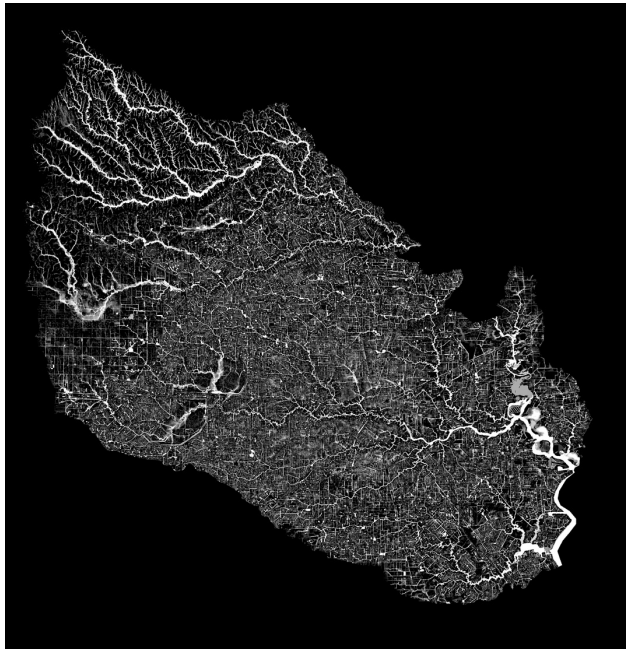
- Can create / implement policies

?? agent

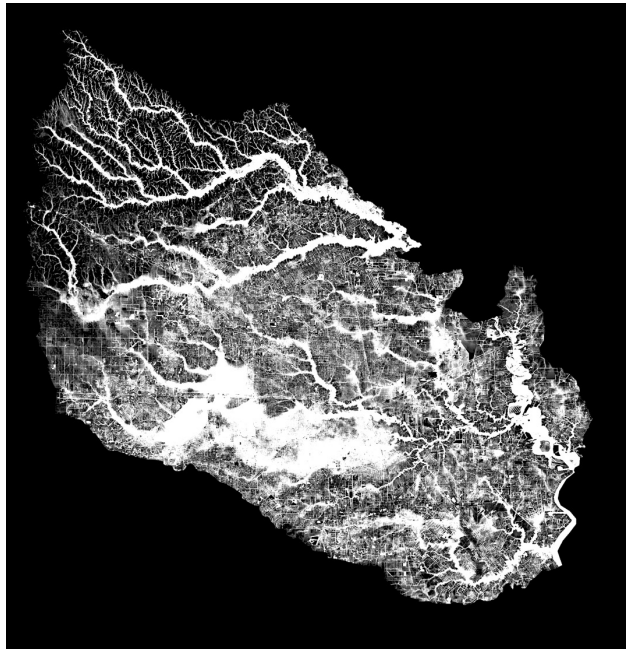
Flood maps



Once in 100 year flood



Once in 500 year flood



Flooding as observed during Hurricane Harvey (2017)

There is an estimated flood depth (what people prepare for) and an actual flood depth when a shock hits!
They can, but do not have to be the same.

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Flood maps to flood damage

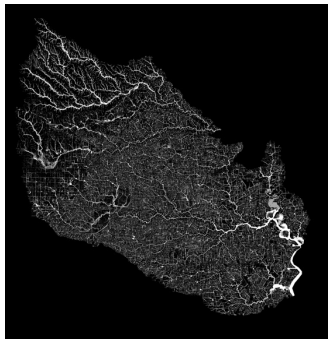
- Flood depths for different scenarios
- Huizinga et al. (2017)
  - Flood depth – damage functions

Water depth (m)	Damage factor
0	0.20
0.5	0.44
1	0.58
1.5	0.68
2	0.78
3	0.85
4	0.92
5	0.96
6	1.00

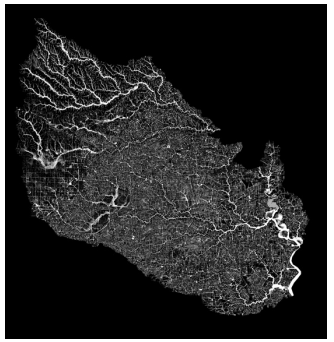
```
if flood_depth >= 6:
    flood_damage = 1
elif flood_depth < 0.025:
    flood_damage = 0
```

```
flood_damage = 0.1746 * math.log(flood_depth) + 0.6483
```

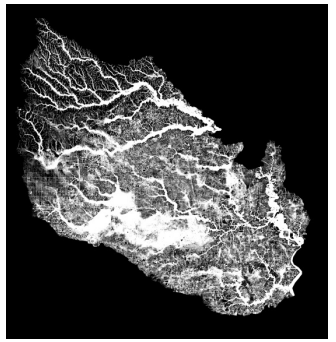
The damage factor is already implemented, to get damage in €/m^2 :
Multiply damage factor with 788€/ m^2



Once in 100 year flood



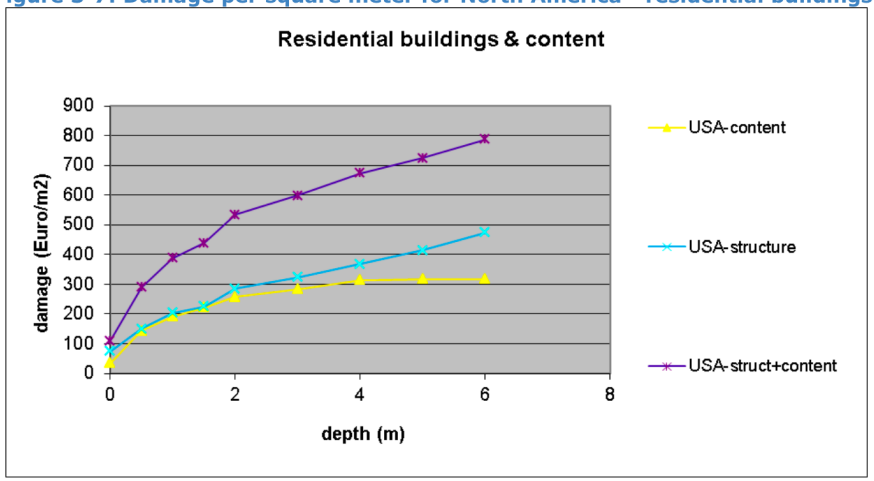
Once in 500 year flood



Flooding as observed during Hurricane Harvey (2017)

North America:

Figure 3-7: Damage per square meter for North America - residential buildings.



All data is from the USA and based on the HAZUS flood damage model (Scawthorn et.al., 2006a/2006b). In the Figure 3-7 above the value of houses is the sum of structure and content damage.

The average maximum damage for North America is 788 €/m^2 (2010) compared to 750 €/m^2 (2007) in Europe.

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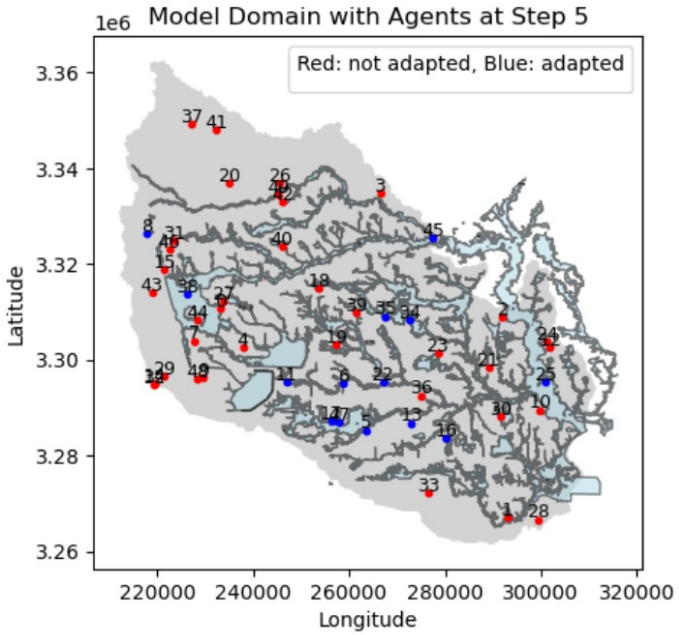
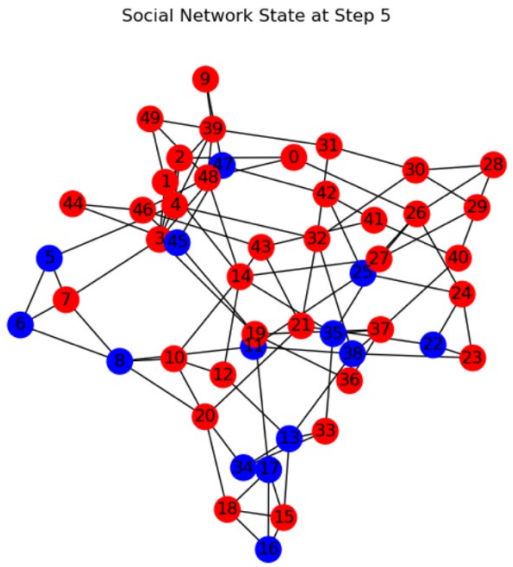
What is does now

- Loads maps
- Creates households
- Places them on a map
- Connects them to other agents





Flood Adaptation: Minimal Model

This python script outlines a basic Agent-Based Model (ABM) developed using the Mesa framework, designed as a simplified representation of household adaptation to flood events in a social network context. The model serves as a template for understanding the fundamental mechanics of flood adapdtation with a given social network.

This directory is structured as follows:

- A Mesa Agent class `Households` is defined in `agents.py`
- A Mesa Agent class `Government` is de… action)
- A Mesa Model class `AdaptationMode…`
- This notebook `demo.ipynb` provides a…

Each agent in the model represents a house… flood events. The flood depth attribute assigned to each household is currently ran… old to adapt is also arbitrary. In a more comprehensive model, this could be replac…

The current implementation includes severa… oths and basic adaptation logic based on random thresholds. These aspects are desi… ed with realistic and sound choices.

You are encouraged to modify, expand, and customize the model. This might include integrating real-world data, implementing more complex decision-making processes for agents, or exploring different network topologies and their effects on social dynamics.

The visualisation provided is basic. Additional aspects can be added for visualization and more in-depth analysis.

This notebook was tested on 2023-11-13 with Mesa version 2.1.4 on Python 3.12.0.

Running the model and visualizing the model domain and social network over time

```
from model import AdaptationModel
import matplotlib.pyplot as plt
import networkx as nx

# Initialize the Adaptation Model with 50 household agents.
model = AdaptationModel(number_of_households=50, flood_map_choice="100yr", network="watts_strogatz")

# Calculate positions of nodes for the network plot.
# The spring_layout function positions nodes using a force-directed algorithm,
# which helps visualize the structure of the social network.
pos = nx.spring_layout(model.G)
```

Omar will go into it in more detail on Thursday!

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Your job

- Expand the model
- You will be assigned different tasks in your group to implement varying mechanisms:
  - Single agent:

    different theories on how households take decisions to adapt → How do households take adaptation decisions

    different metrics to trigger adaptation responses from the government
  - Agent interaction

    different ways agents can interact

    → how do households influence each other?

    → how do governmental institutions interact?
  - Among others

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How I used the model for my work

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- Started as a master thesis for EPA
- Expanded and adjusted it for my PhD
- Currently writing it up for publication

This is not, what you need to do,
but to give some insights of what the minimal model could lead to.

Basic idea

- Households adaptation is based on perceptions
  - Social influence plays an important role, but we don't know what role exactly

→ What role does social influence play in the adaptation of households against flooding?

→ How do these effects accumulate across society?

→ How are information policies impacted by social influence?

- Climate Change adaptation across scales

Level of Climate Change Adaptation		
Macro	Meso	Micro

The household agents

What can households do to protect against flooding?

“High Effort Measures”

“Low Effort Measures”

Here: 10 different measures

- 5 structural
- 5 non-structural

Source: Noll et al (2021) “Contextualizing cross-national patterns in household climate change adaptation” **Nature Climate Change**, 1-6

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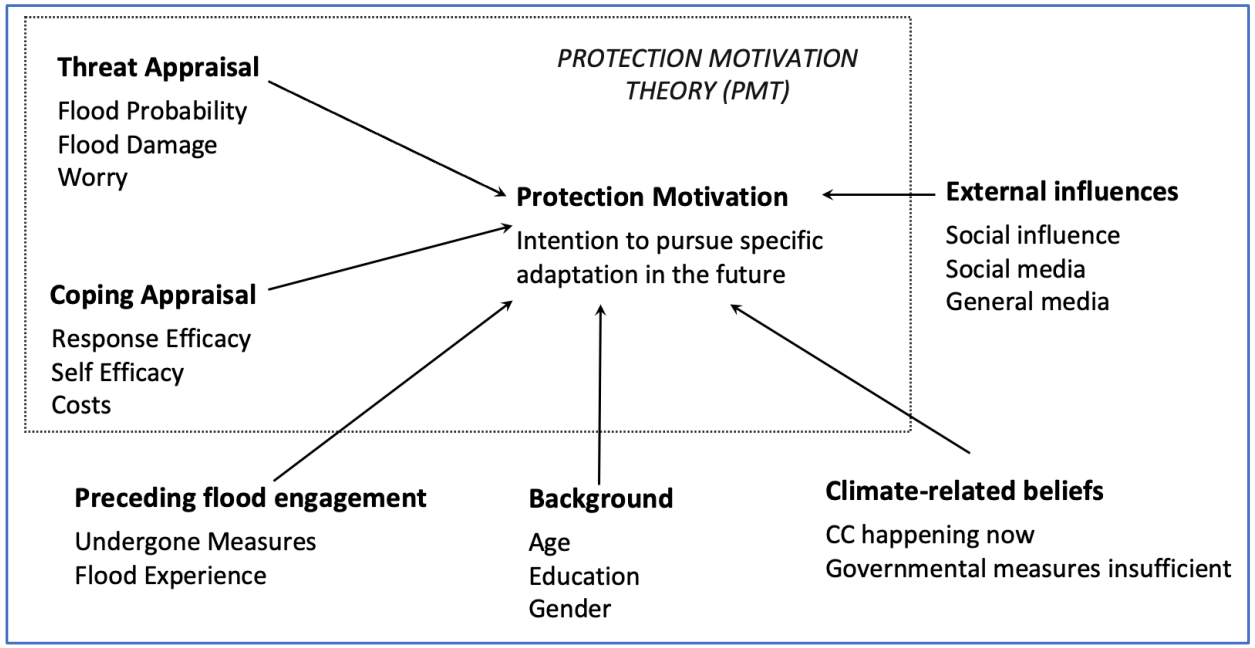
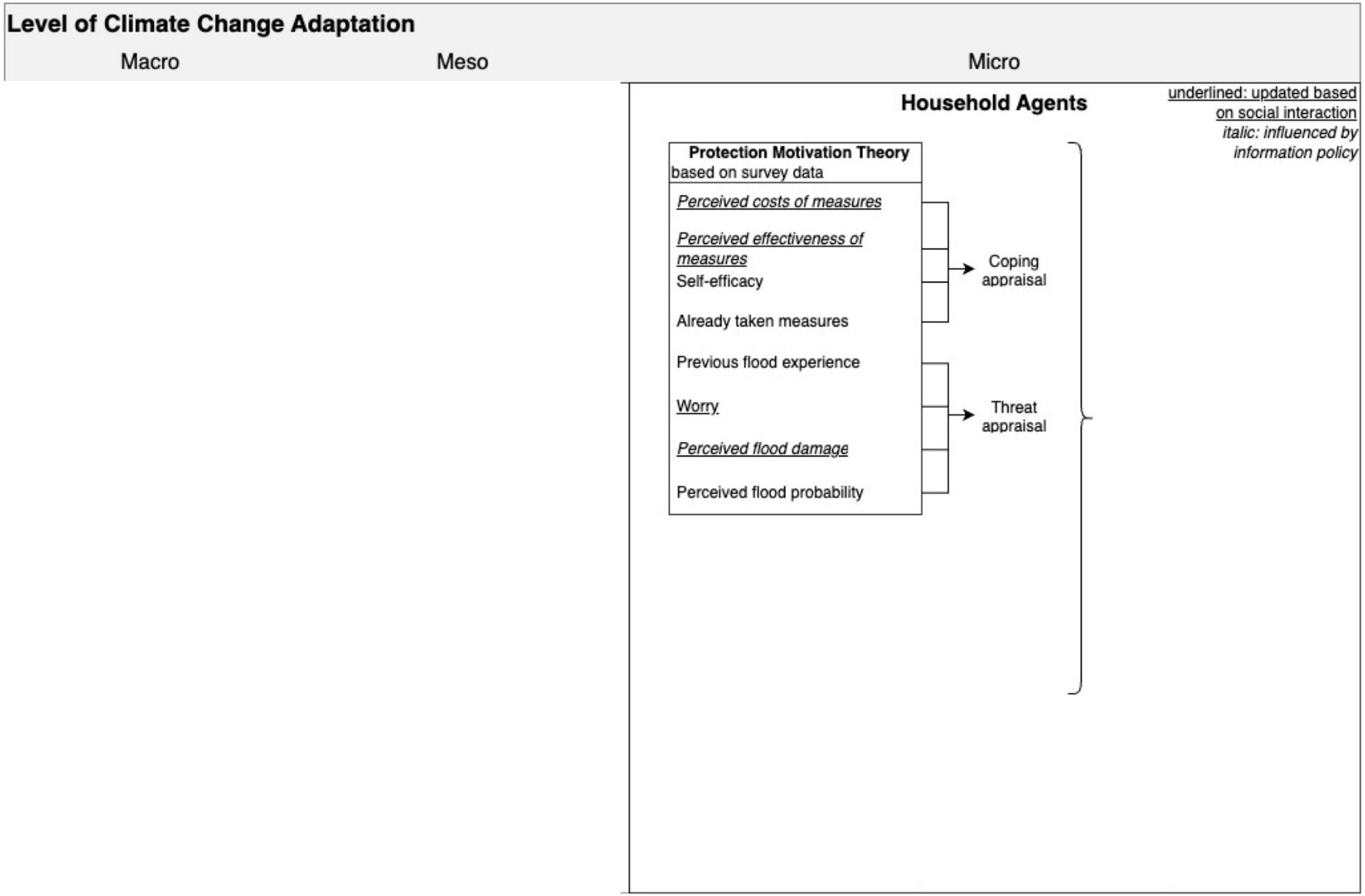
The household agents

- How do households decide to adapt?



Household survey data from April 2020

The household agents



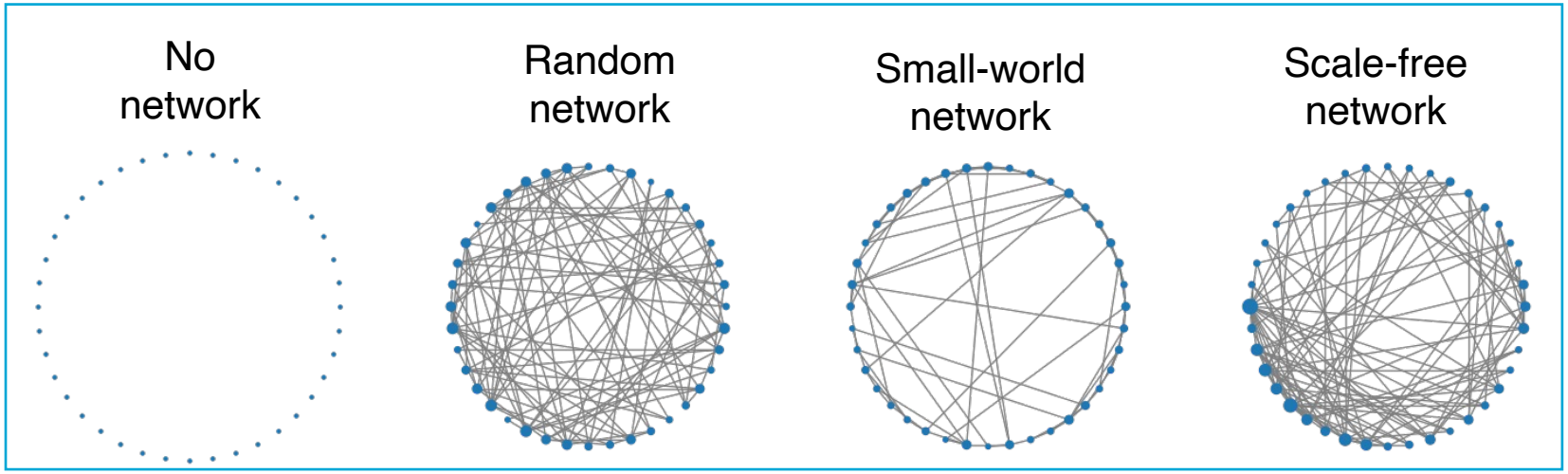
Social interaction

- How do the social interactions related to climate change adaptation look?

→ We don't know

→ Structural testing!

What is the network structure?



How do they adapt their opinion?

- Assimilative social influence (Degroot model)

What do they exchange?

- Threat:
  - Worry
  - Perceived flood damage
- Coping
  - Perceived costs of measures
  - Perceived effectiveness

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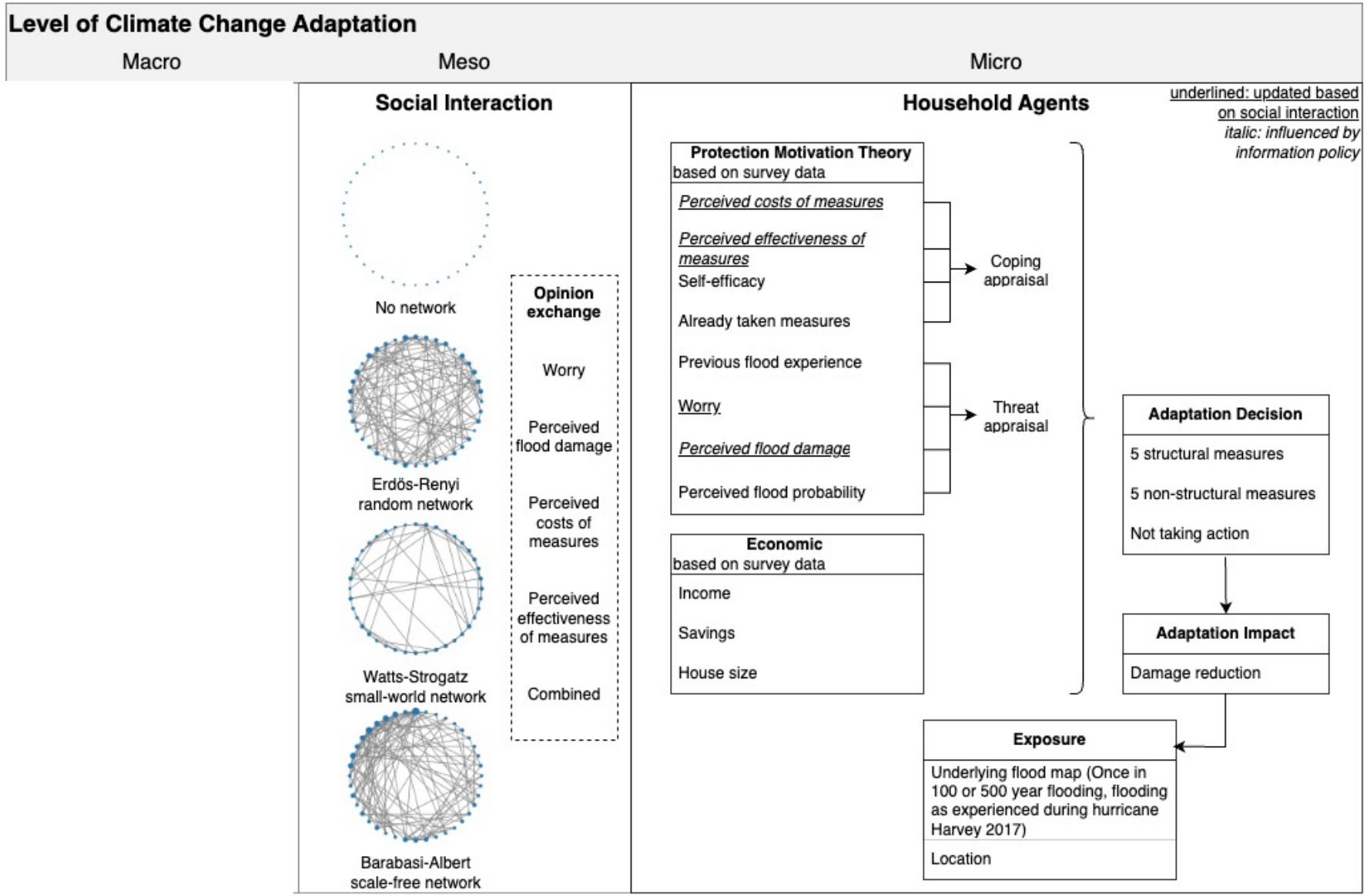
Adding social interaction



Information policies

Scope

Providing information on

- Threat
  - Flood risk at the households location
- Coping
  - Costs of measures
  - Effectiveness of measures

Severity

Varying the risk information according to 3 scenarios

Selectivity

- Providing all households with information
- Providing only the households in the floodplain with information

How?
Extra node sending this information

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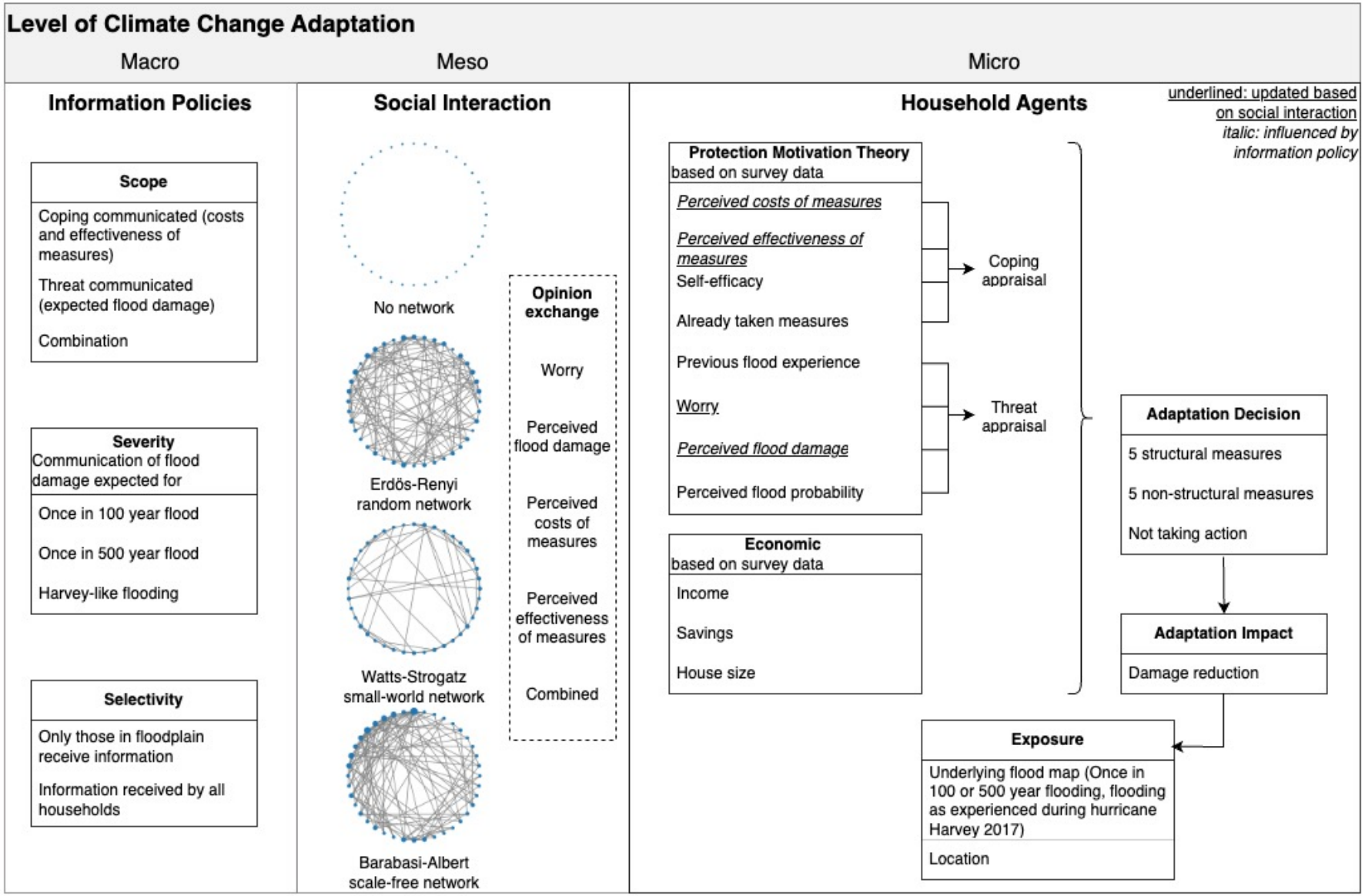
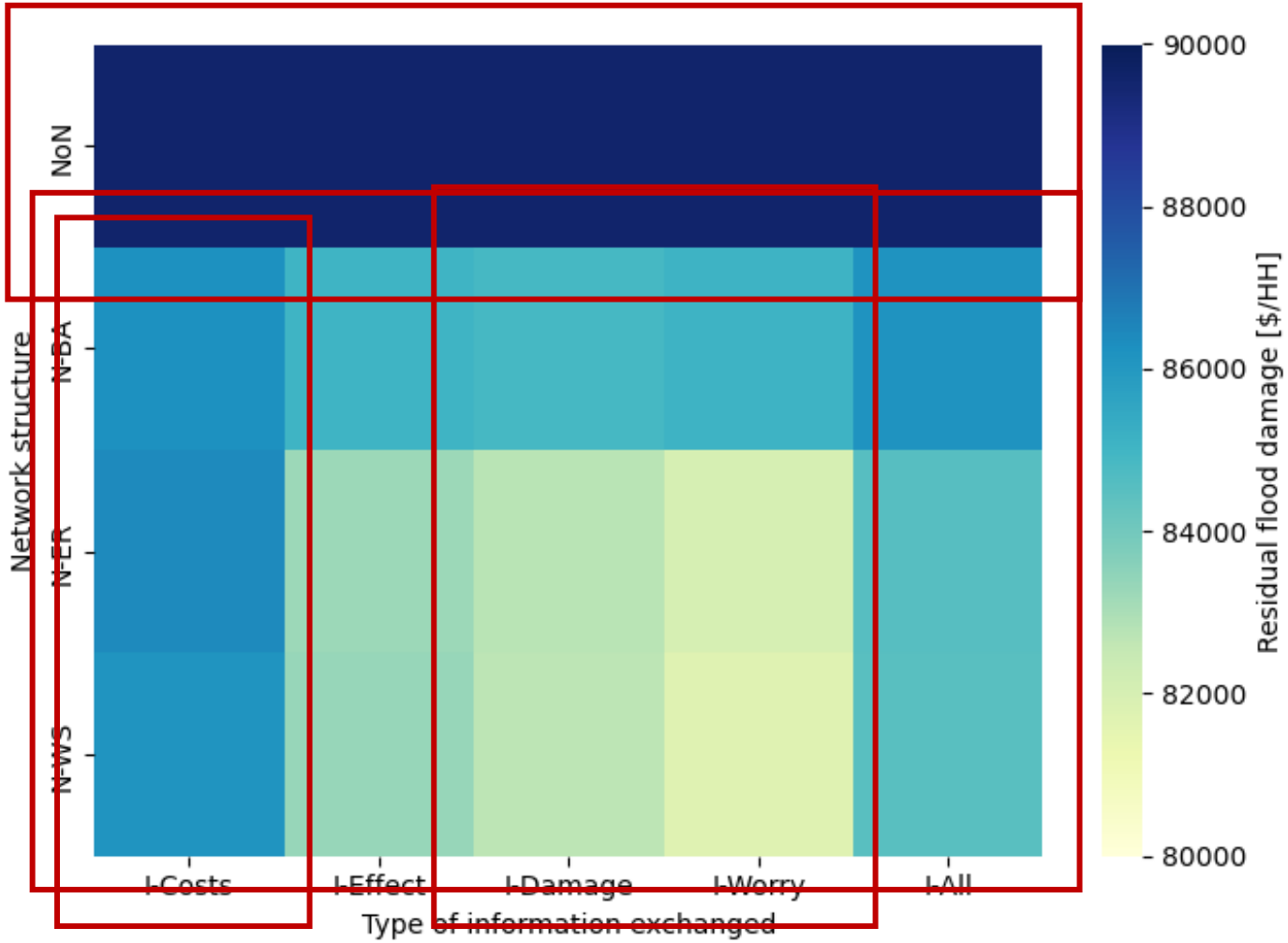
Adding policies



Results – social interaction

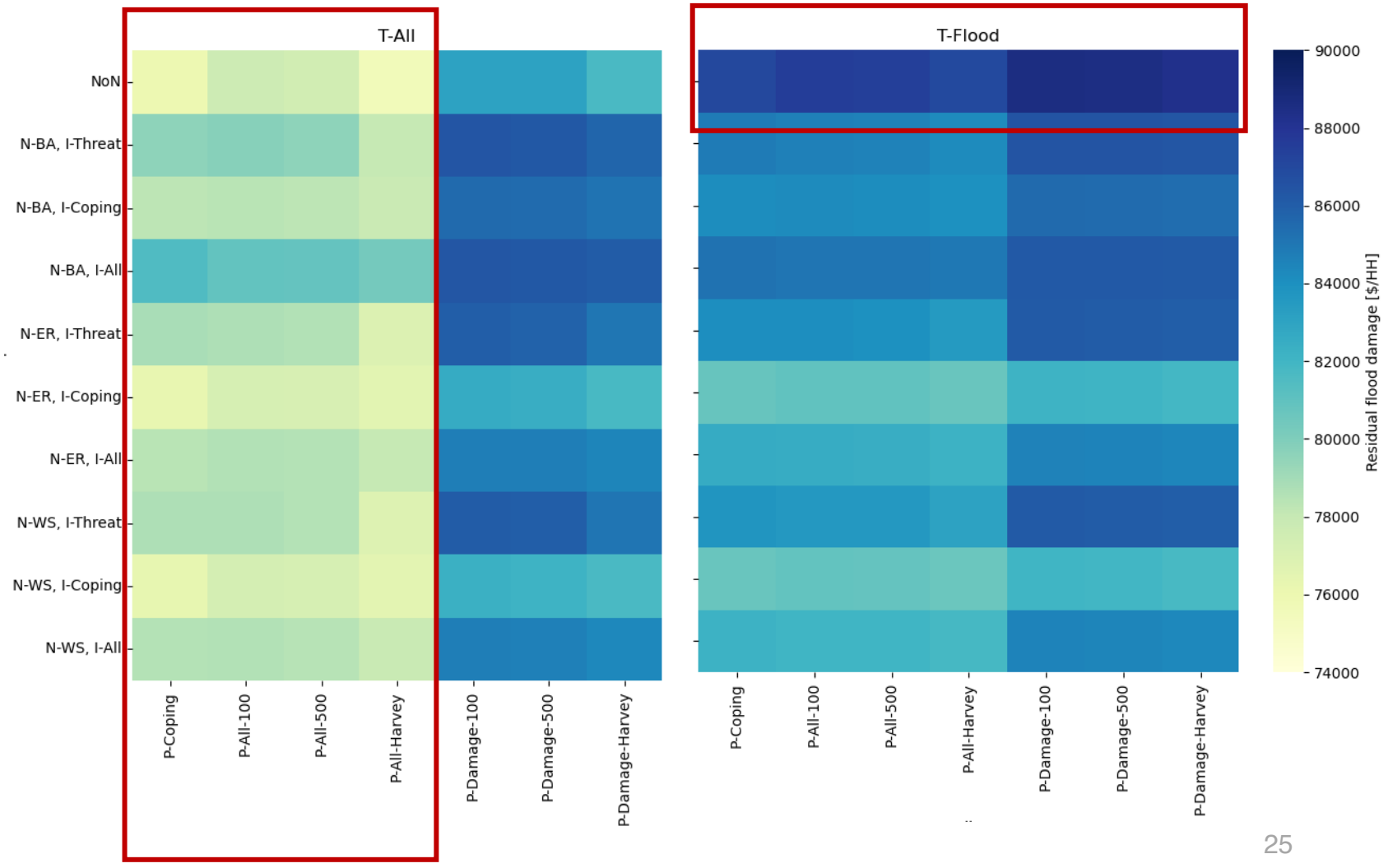
Social interaction matters!

- Different network structures lead to different diffusion
- Exchanging threat leads to more adaptation



Results – Information policies

- Information diffusion makes a difference!
- Risk communication not as effective as coping communication



What have I learned from this model?

- Social interaction matters!
  - It considerably influences adaptation decision
  - There are differences between different network structure and what is exchanged
  - → We need to do some research on how it actually works so we design policies based on it.

- Information policies are effective
  - Social interaction effects can be beneficial for spreading information
  - Informing about coping much more effective than informing about risks (which currently often happens)

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Thank you for your attention!
Questions?

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