EGU General Assembly 2022

Exploring Behavioral Determinants of Flood Insurance Adoption with Explainable Machine Learning in the Continental US

Nadja Veigel[1,2,3], Heidi Kreibich[2], Andrea Cominola[1,3]

[1]Chair of Smart Water Networks, TU Berlin –
[2]GFZ German Research Centre for Geosciences
[3]Einstein Center Digital Future Berlin

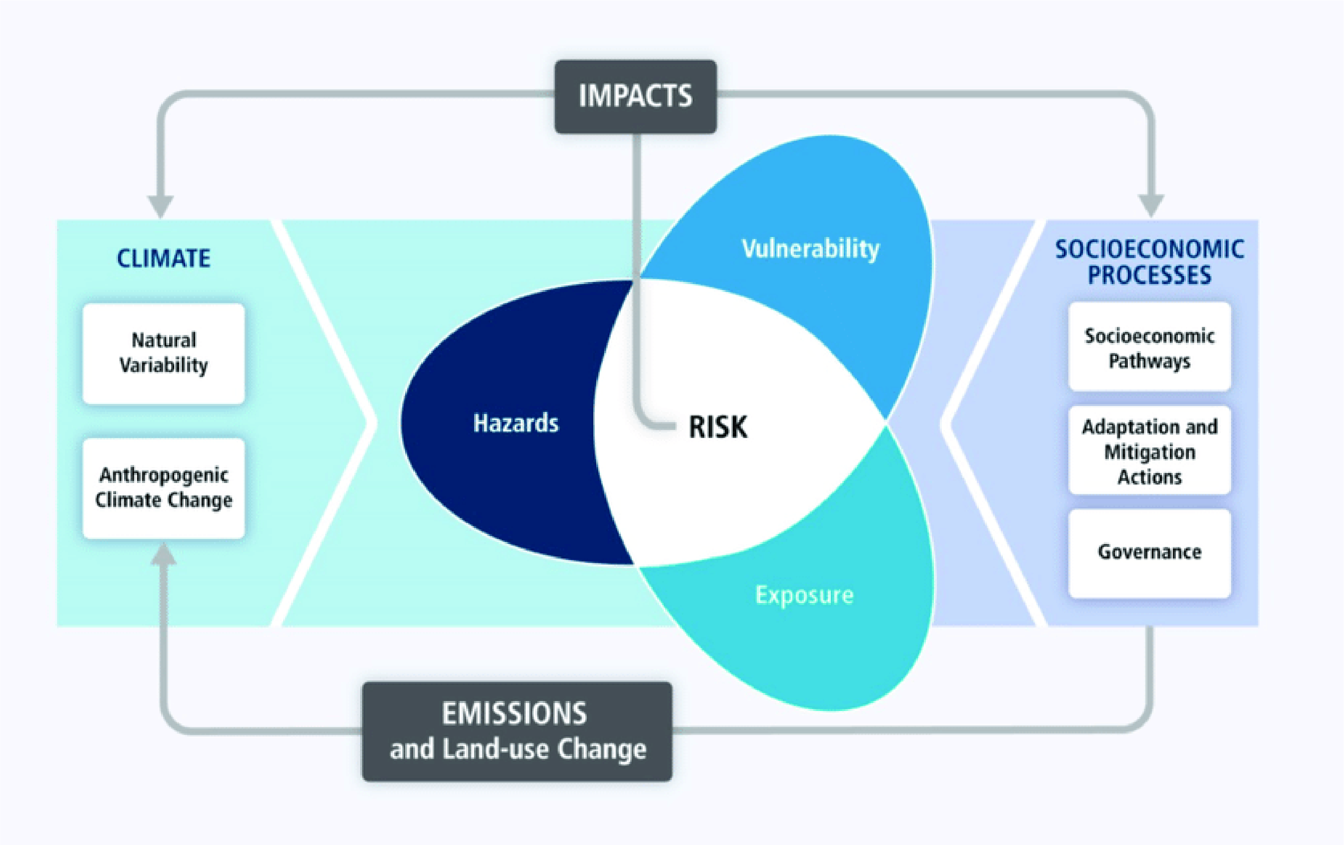
27.05.2022 | Session NH9.3

REGISTERED AS OSPP !

HEIBRIDS
HELMHOLTZ EINSTEIN INTERNATIONAL BERLIN RESEARCH SCHOOL IN DATA SCIENCE

Image:http://www.noaanews.noaa.gov/stories2005/images/katrina-fishing-vessels-stranded-empire-la-08-29-2005.jpg

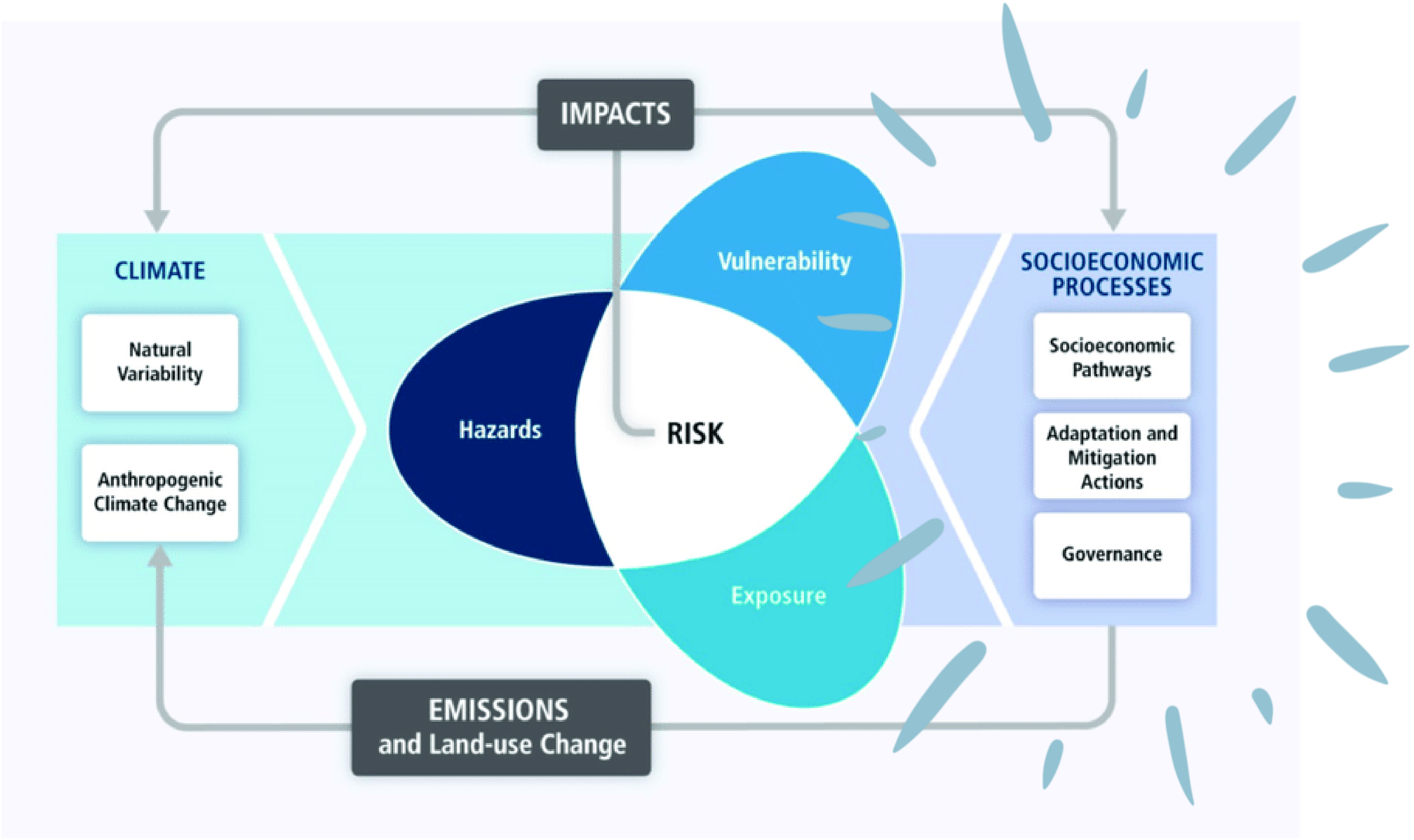
OVERARCHING RESEARCH QUESTION



How do heterogeneous socio-demographic characteristics and human behaviors influence flood resilience?

Source: IPCC, 2012

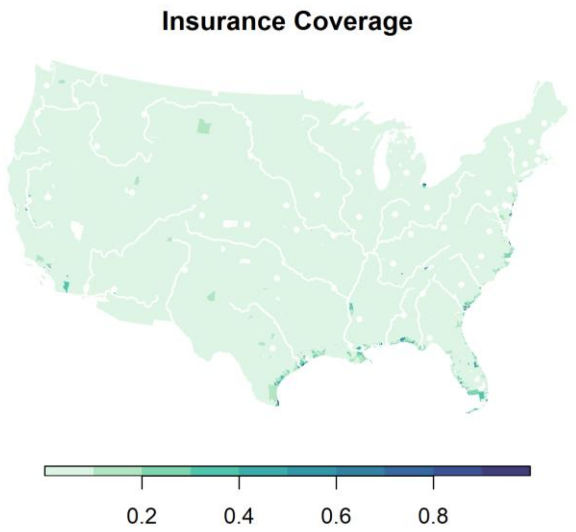
OVERARCHING RESEARCH QUESTION

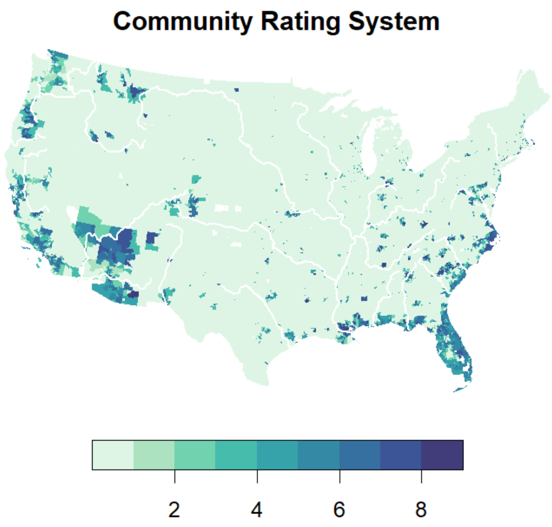


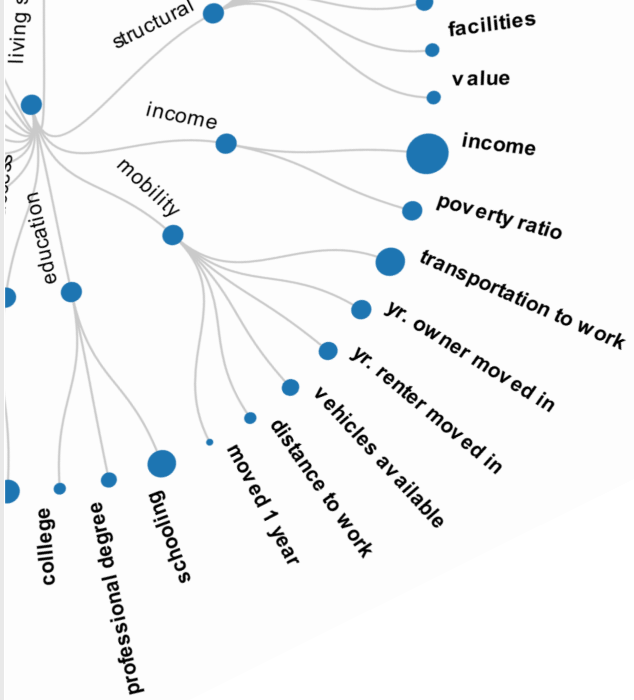
How do heterogeneous socio-demographic characteristics and human behaviors influence flood resilience?

Source: IPCC, 2012

DATA







target

input

. Insurance data from 2009 to 2020:

54.871.946 records

. Active insurance policies in 2020: 5.1 million households

. In 2017:

22,200 communities

. only 6.5% of communities participate

. over 69% of flood insurance policies are in CRS communities

Data from the 2018 **US community survey**

. census tract scale

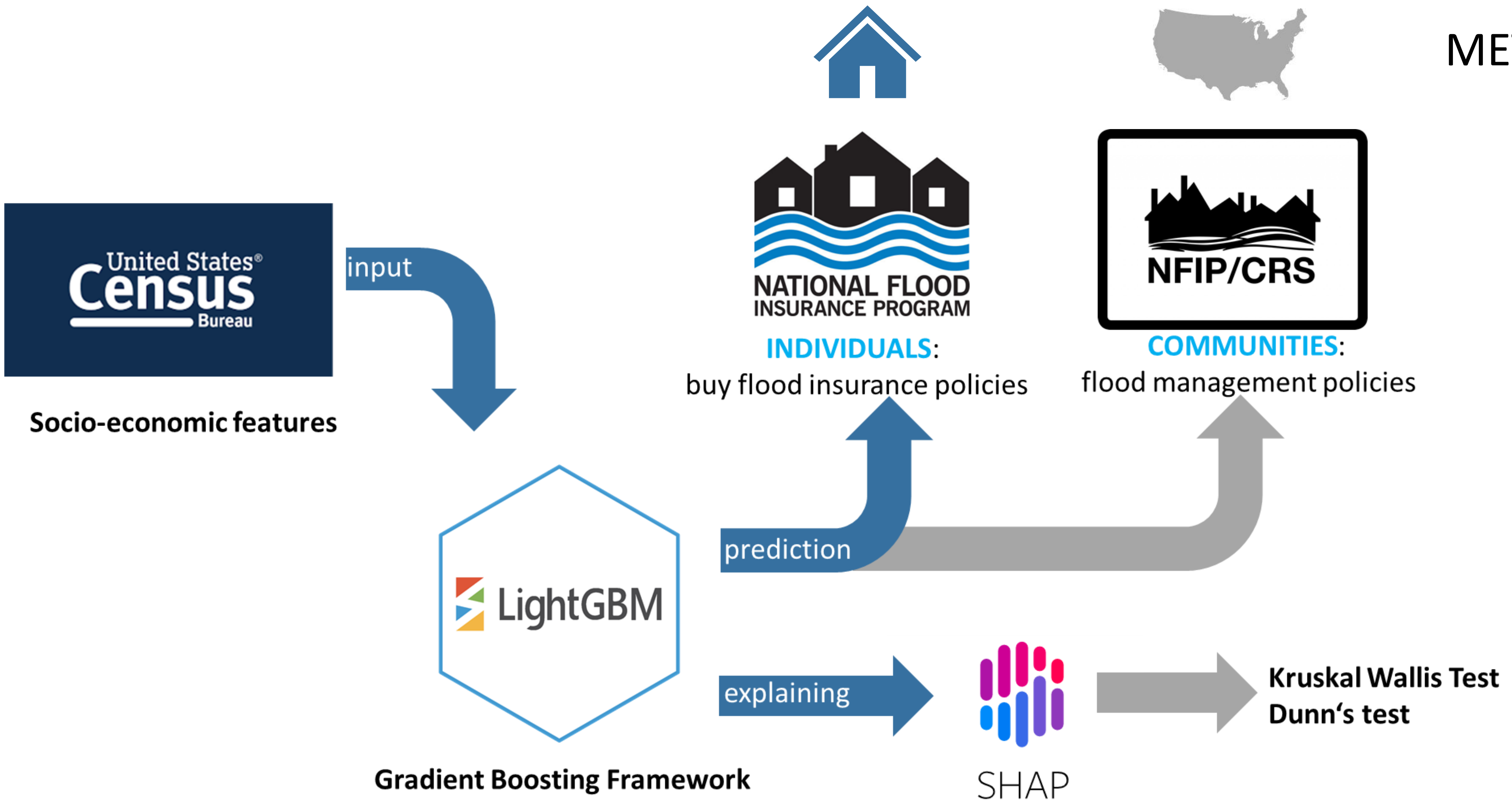
. **hierarchical system** grouped with mix of expert-based and high-level hierarchy selection

Total number of variables after selection:

398

Source: https://www.fema.gov/openfema-data-page/openfema-dataset-fima-nfip-redacted-policies--v1

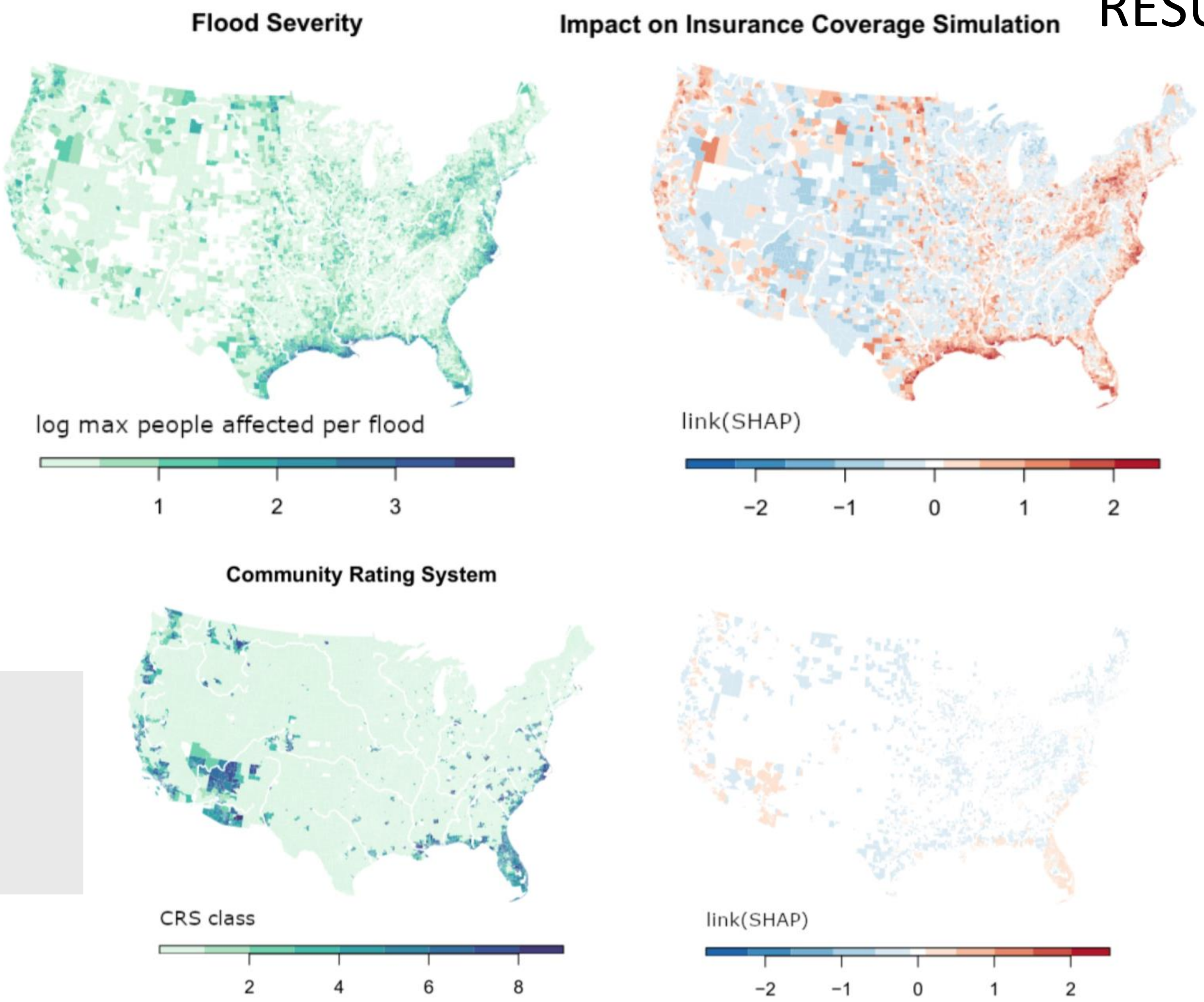
METHOD



https://census.gov
https://github.com/slundberg/shap
https://joefloodrossi.com/wp-content/uploads/2016/01/nfip_crs_logo-scaled.jpg
https://149448276.v2.pressablecdn.com/wp-content/uploads/2019/03/national-flood-insurance-program-nfip-logo.jpg
https://user-images.githubusercontent.com/7608904/90947747-e2d40c00-e3fd-11ea-9472-fc79e1a20bd9.png

RESULTS

OWNERSHIP, FLOOD HISTORY, and CRS matter more than many socio-demographics variables.

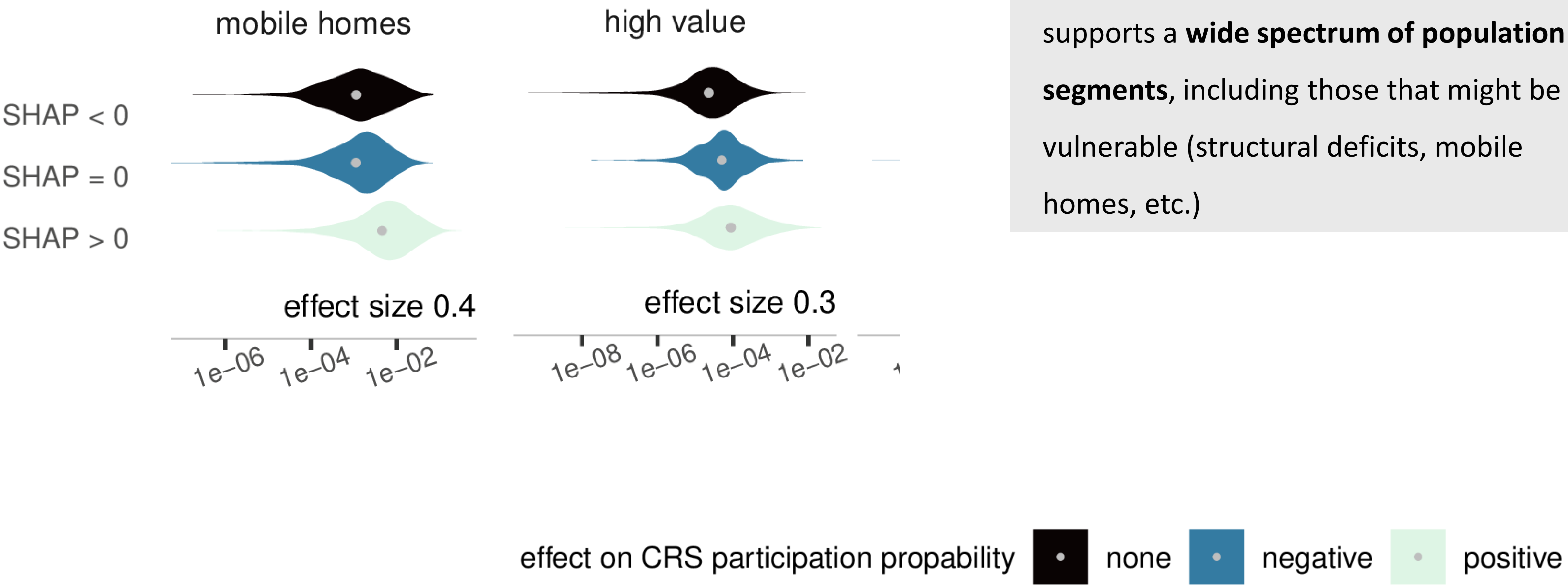


Analysis of the Community Rating System suggests that **POLICIES** were effective in promoting flood insurance purchase.

Are there inequalities? Is the CRS “favoring” specific socio-demographic categories ?

CRS COVERS HETEROGENEOUS SOCIO-ECONOMIC BACKGROUNDS

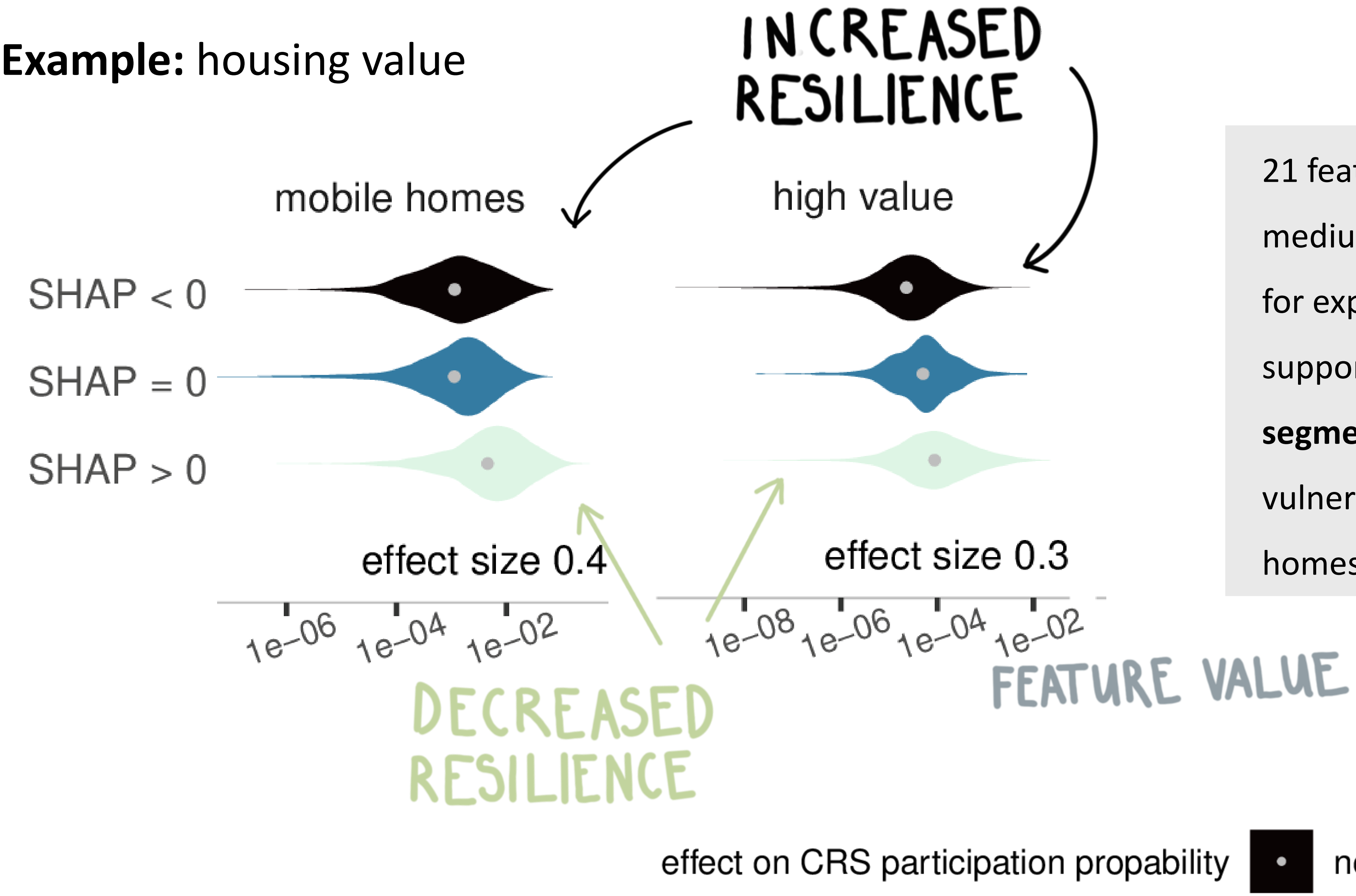
example: housing value



21 features showed differences with a medium to strong effect size corrected for exposure. The CRS apparently supports a **wide spectrum of population segments**, including those that might be vulnerable (structural deficits, mobile homes, etc.)

CRS COVERS HETEROGENEOUS SOCIO-ECONOMICS

Example: housing value



21 features showed differences with a medium to strong effect size corrected for exposure. The CRS apparently supports a **wide spectrum of population segments**, including those that might be vulnerable (structural deficits, mobile homes, etc.)

TAKE-HOME MESSAGES

. HOUSEHOLD FLOOD INSURANCE PURCHASE

ownership, experience, exposure, and policies matter more than socio-demographics. Reactive behaviors following severe events.

. CURRENT POLICIES (Community Rating System)

CRS (community measure) encourages resilience measures at the individual level (insurance purchase) in an inclusive and non-discriminatory way. Hence, public policies seem to effectively support private initiatives.

thank you

Nadja Veigel
Heidi Kreibich
Andrea Cominola

Technische Universität Berlin
Geoforschungszentrum Potsdam
Einstein Center Digital Future

nadja.veigel@tu-berlin.de

PLEASE ENTER YOUR FEEDBACK IN THE OSPP PORTAL

image: https://upload.wikimedia.org/wikipedia/commons/9/9f/KatrinaNewOrleansFlooded.jpg

REFERENCES

Cardona, O.D., M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, R.S. Pulwarty, E.L.F. Schipper, and B.T. Sinh, 2012: Determinants of risk: exposure and vulnerability. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 65-108.

Haer, T., Botzen, W.W. and Aerts, J.C., 2019. Advancing disaster policies by integrating dynamic adaptive behaviour in risk assessments using an agent-based modelling approach. Environmental Research Letters, 14(4), p.044022.

IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker,
D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

Lundberg, S.M., Erion, G., Chen, H. et al. From local explanations to global understanding with explainable AI for trees. Nat Mach Intell 2, 56–67 (2020). https://doi.org/10.1038/s42256-019-0138-9

Guolin Ke, Qi Meng, Thomas Finley, Taifeng Wang, Wei Chen, Weidong Ma, Qiwei Ye, Tie-Yan Liu. "LightGBM: A Highly Efficient Gradient Boosting Decision Tree". Advances in Neural Information Processing Systems 30 (NIPS 2017), pp. 3149-3157.

Sadiq, A.-A., Tyler, J., Noonan, D. S., Norton, R. K., Cunniff, S. E., & Czajkowski, J. (2020). Review of the Federal Emergency Management Agency's Community Rating System Program. In Natural Hazards Review (Vol. 21, Issue 1, p. 03119001). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/(asce)nh.1527-6996.0000320

Schrieks, T., Botzen, W., Wens, M.L., Haer, T. and Aerts, J., 2021. Integrating behavioral theories in agent-based models for agricultural drought risk assessments. Frontiers in Water, 3, pp.1-19.

Wing, O.E., Lehman, W., Bates, P.D., Sampson, C.C., Quinn, N., Smith, A.M., Neal, J.C., Porter, J.R. and Kousky, C., 2022. Inequitable patterns of US flood risk in the Anthropocene. Nature Climate Change, 12(2), pp.156-162.

Winsemius, H.C., Aerts, J.C., Van Beek, L.P., Bierkens, M.F., Bouwman, A., Jongman, B., Kwadijk, J.C., Ligtvoet, W., Lucas, P.L., Van Vuuren, D.P. and Ward, P.J., 2016. Global drivers of future river flood risk. Nature Climate Change, 6(4), pp.381-385.