Supplementary Material

Supplementary section 1 Comparison to reported damages

Risk is defined as the product of hazard, exposure and vulnerability and expressed as the expected annual damage (EAD) in this paper. The hazard component is comprised of layers of inundation extent and depth for nine return periods (50% to 0.1% annual exceedance probability). The inundation associated with each return period is assumed to occur everywhere simultaneously and we calculate the expected annual damage as the integral of the exceedance probability-impact curve. With this probabilistic analysis the total EAD for Ethiopia in our model is $213.2mln/yr ($46.7mln/yr for rural and $166.6mln/yr for urban areas).

The validation of risk values is difficult as publicly available losses for flood events especially in developing countries, are, if observed at all, rough estimates and often limited to low-frequency, high-impact events. However, we believe that it is important to show the order of magnitude of the losses from the model compared to those in loss databases, even though this is difficult. Therefore, we compared our results with losses reported in the NatCatSERVICE provided by MunichRe (Munich Re, 2016). The NatCatSERVICE database covers global flood loss information from 1980 to 2016. After normalizing those values to 2016 by accounting for inflation and changes of population and wealth since the year of the event, the average damage for Ethiopia is $83mln/yr. It should be stressed that this is simply the average damage per year of the period 1980 to 2016, rather than begin based on a probabilistic approach. Therefore, the modelled and observed metrics are different, since the reported losses do not include information on all flood probabilities. Notwithstanding, the average of the reported losses is significantly lower than our estimated EAD, although they are of a similar order of magnitude. It is to be expected that simulated values are higher than reported values, as not all flood events are recorded in the NatCatSERVICE database (Kron et al., 2012). Generating the flood events and their damages stochastically would be a different approach to calculate the risk or might be used to support a dataset of reported losses as the synthetic realizations could extend missing parts of the exceedance probability-impact curve. However, this also would raise the question of the validation of those risk results and validation of the stochastic generated hazard layer of the events.

In our flood risk assessment we assume that Ethiopia is only protected against floods with a return period of 2 years, whilst in reality there may be higher flood protection in place for the most flood-prone areas, especially in the main urban areas. Estimates of EAD are very sensitive to the assumed protection standard (Ward et al., 2017). For example, if we assumed that Ethiopia was protected against floods with a return period of 5 years, the EAD would fall to $124.5mln/yr ($96.3mln/yr urban, $28.2mln/yr rural) which is similar to the country's flood risk ($135.5mln) in the 2015 Global Assessment Report (UNISDR, 2015) .

Supplementary table 1 Confusion matrix of urban settlement map of the ImageCat data as reference with different classification maps.

		ImageCat	
		Other land use	Settlement (urban)
GRUMP	Other land use	9,967	7,363
	Settlement	33	2,637
MOD500	Other land use	9,995	9,403
	Settlement	5	597
GUF	Other land use	9,997	8,792
	Settlement	3	1,208
HBASE	Other land use	9,999	8,618
	Settlement	1	1,382
GHS-SMOD	Other land use	9,855	5,150
	Settlement (urban centre/cluster)	145	4,850
GHS-SMOD	Other land use	9,855	5,150
	Settlement (urban centre)	145	4,850

Supplementary table 2 Confusion matrix of urban-rural map of the ImageCat data as reference with GHS-SMOD as classification maps.

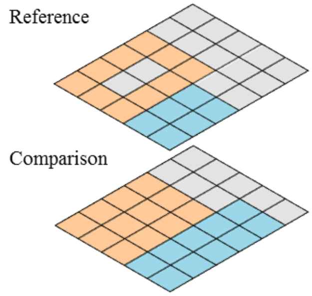
		ImageCat		
		Other land use	Rural	Urban
GHS-SMOD	Other land use	9,484	8,231	3,123
	Rural	411	1,101	2,004
	Urban (centre/cluster)	105	668	4,873

Supplementary table 3 Results of agreement for Ethiopia using the ImageCat data classified to urban settlement and other land use as the reference map.

Settlement Map	Settlement (urban)		Other land use		Overall Accuracy (%)	Kappa
	Producer's Accuracy (%)	User's Accuracy (%)	Producer's Accuracy (%)	User's Accuracy (%)		
GRUMP	26.4	98.8	99.7	57.5	63.0	0.26
MOD500	6.0	99.2	100.0	51.5	53.0	0.06
GUF	12.1	99.8	100.0	53.2	56.0	0.12
HBASE	13.8	99.9	100.0	53.7	56.9	0.14
GHS-SMOD (urban centre/cluster)	48.5	97.1	98.6	65.7	73.5	0.47
GHS-SMOD (urban centre)	25.0	99.2	99.8	57.1	62.4	0.25

Supplementary table 4 Building footprints for sensitivity analysis derived from the ImageCat data of flood risk assessment for Ethiopia.

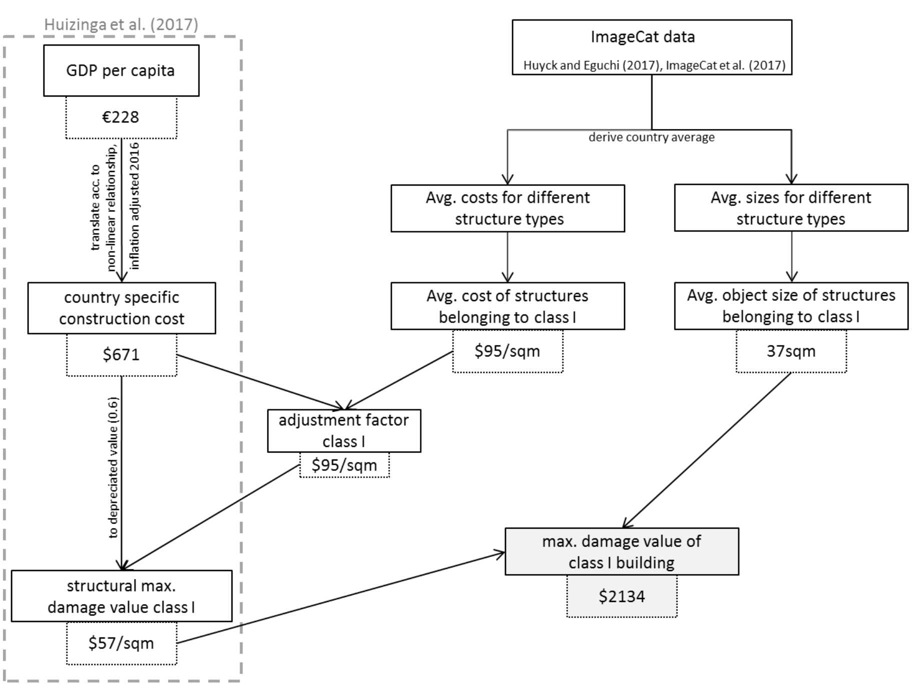
Vuln. class	Building footprint [m^2]
I	35
II	35
III 1 floor	35
III 2 floors	251
IV	467



		Reference			
		Class 1	Class 2	Class 3	Sum
Comparison	Class 1	p_{11}	p_{12}	p_{13}	$p_{1\_}$
	Class 2	p_{21}	p_{22}	p_{23}	$p_{2\_}$
	Class 3	p_{31}	p_{32}	p_{33}	$p_{3\_}$
	Sum	$p_{\_1}$	$p_{\_2}$	$p_{\_3}$	1

Metric	Equation	Short Explanation
Overall accuracy	$OA = \sum_{j=1}^{q} p_{jj}$	proportion of samples classified correctly; refers to the probability that a randomly selected location on the comparison map is classified correctly
Kappa	see Congalon (1991)	agreement between the maps, corrected for the agreement as can be expected from random allocation of classes
Producer's accuracy	$P_j = p_{jj} \ / \ p_{\_j}$	proportion of the samples of reference class j that is mapped as class j; probability that class j in the reference is mapped as the same class
User's accuracy	$U_i = p_{ii} \ / \ p_{i\_}$	proportion of the samples mapped as class i that has reference class i; probability that an area of class i on the comparison map is also that class in the reference

Supplementary figure 1 Example accuracy assessment using a confusion matrix of q classes and p_{ij} representing the proportion of samples that has classification class i and reference class j.



Supplementary figure 2 Process of calculating the maximum damage value for the example of a class I building.

References

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