

## GIS-FSLAM-FORM: A QGIS plugin for fast probabilistic susceptibility assessment of rainfall-induced landslides at regional scale Hongzhi Cui, Marcel Hürlimann, Vicente Medina, Jian Ji Department of Civil and Environmental Engineering, UPC BarcelonaTECH, 08034, Barcelona, Spain Geotechnical Research Institute, Hohai University, 210024, Nanjing, China,

### **Research Motivation & Study Goals**

#### **Research motivation:**

- Landslide susceptibility assessment
- Fast Shallow Landslide Assessment Model (FSLAM)
- First order reliability mehod (FORM-HLRF\_x)

#### Study goals:

- GIS-FLSAM-FORM plugin developed
- Parameter uncertainties in regional scale
- Factor of safety(FoS), Reliability index(RI), Failure probability (Pf)





#### Soil properties:

soil cohesion, friction angle, density, hydraulic conductivity and soil thickness

- LULC: the root cohesion (Cr)
- CN: curve number
- Rainfall information: antecedent rainfall & event rainfall

# **Results of software developed: GIS-FSLAM-FORM**

SIE	n	lugin
	μ	uyiii

M_FORM X				Q QGIS_FSLAM_FORM >							
Dutputs:Slope stability	Information		Inputs	Outputs:Slope stability	Information		Inputs	Outputs:Slope stability	Information		
Input data files ter files(.tif) and data files(.csv)			Salaat	Stability modelling outputs			GIS-FSLAM-FORM				
don Model(dem.dl)		•	Select	the desired output mes for	are stating modeling	Б	-	ast Shattow Lanastia	Assessment Mouer		
es(soil.tif)			✓ PoF	after antecedent and even	ıt rainfall		The plugi	n integrates a simplified h	ydrological model and the		
		•	PoP ▼	✓ PoF after antecedent rainfall			slope theory, and can perform probabilistic stability analysis				
d Land Cover (lulc.tif)			<b>✓</b> FS	✓ FS after antecedent and event rainfall				short time. Thus it is a useful tool to calibrate parameters an			
	•	•	□ □ FS	FS after antecedent rainfall			regional landslide susceptibility.				
rainfall or effective rechar,	ge (rain_ant.tif)	•] [		onditionally stable cells (M	lontgomery and Diet	rich,1994)					
gering rainfall (rain event	Ltif)		Ū Unc	onditionally unstable cells (	Montgomery and D	ietrich,1994)		×			
· · · · ·		•][	Sat	tration degree after Pa (ha/	′z)						
es (soil.csv)			▼ Par	t of Pe that infiltrates							
		•	3 ac	iditional topographic raster	s (fillsinks, slope, flo	w accumulation)		Fast Sha	low Landslide Assessr		
d land cover (hmtu.csv)				Cl. Cd. 2 1	1	+ 10001	Referenc	es cited in the plugin:			
er (CN csv)				a mes of the 5 items denne	d in Eq 9 of Medina	ret al 2021	(1) Hürlim:	ann, M., Guo, Z., Puig-Polo, G	C. et al. Impacts of future clima		
		•][					changes o	on landslide susceptibility: re	gional scale modelling in the		
es marker values(HSG-val	ue.csv)		The pa	th o <mark>f t</mark> he output folder(aotu	matic after run)		(Pyrenees	, <mark>S</mark> pain). <i>Landslides</i> 19, 99–1	18 (2022).		
		•][	D:/00	IS-Test/RES			(2) Ji, J., C	ui, H., Zhang, T. et al. A GIS-I	based tool for probabilistic ph		
elationship matrix (5 paran	n <mark>eters)(Coef-1.csv)</mark>		_				and predic	tion of landslides: GIS-FORM	M landslide susceptibility ana		
					run	close	Landslide	s 19, 2213–2231 (2022).			
elationship matrix (/ paran	neters)(Coef-2.csv)						(3) Medina	a et al.(2021): Fast physically	-based model for rainfall-indu		
							susceptibi	lity assessment at regional s	cale. <i>Catena</i> , <mark>2</mark> 01 (2021): 1052		

#### Windows software

Windows PowerShell $ imes$	+   ~			Data O	
:\Users\hzcui\AppData\ hon\plugins\qgis_fslam sers\hzcui\AppData\Roa \plugins\qgis_fslam_fo sers\hzcui\AppData\Roa \plugins\qgis_fslam_fo 100.0 0.0 100.0	<pre>\Roaming\QGIS\QGIS3\ n_form\PyGIS-FSLAM-F aming\QGIS\QGIS3\pro orm\PyGIS-FSLAM-FORM aming\QGIS\QGIS3\pro orm\PyGIS-FSLAM-FORM</pre>	<pre>ofiles\defailes\df</pre>	efault .exe ult\py ult\py	<ul> <li>Results</li> <li>GIS-FSLAM-F</li> <li>cumflow.tif</li> <li>Infiltration.tif</li> <li>initial_h_z.tif</li> <li>Iteration_failure_final_cond.tif</li> <li>Iteration_FSLAM.tif</li> <li>Iteration_initial_cond.tif</li> <li>Iteration_uncond_stable.tif</li> <li>Iterstep_uncond_unst.tif</li> <li>PROB_failure_final_cond.tif</li> </ul>	ORM.exe PROB_uncond_uns PROB_uncond_uns RI_failure_final_cor RI_failure_initial_cor RI_failure_initial_cor RI_FSLAM.tif RI_uncond_stable.t RI_uncond_unst.tif SF_antecedent.tif SF_event.tif SF_final_cond.tif SF_final_cond.tif SF_final_cond.tif SF_initial_cond.tif SF_initial_cond.tif SF_initial_cond.tif SF_initial_cond.tif SF_initial_cond.tif SF_initial_cond.tif SF_initial_cond.tif
59290027618408				<ul><li>PROB_failure_initial_cond.tif</li><li>PROB_FSLAM.tif</li></ul>	<ul><li>SF_uncond_stable:</li><li>SF_uncond_unst.tif</li></ul>

### References

• Medina, V., Hürlimann, M. et al. (2021). Fast physically-based model for rainfall-induced landslide susceptibility assessment at regional scale. Catena, 201, 105213.

Ji, J., Cui, H., Zhang, et al. (2022). A GIS-based tool for probabilistic physical modelling and prediction of landslides: GIS-FORM landslide susceptibility analysis in seismic areas. Landslides, 19(9), 2213-2231.

### inancial support of the China Scholarship Council (CSC: 202206710014) for his research at UPC BarcelonaTECH.

hongzhi.cui@upc.edu

### Study area & Datasets





• The plugin enables the calculation of regional landslide susceptibility by considering the influence of both antecedentand and event rainfall conditions. • The HLRF\_x reliability method based on the FORM has been firstly integrated into the FSLAM model. • The results demonstrate that the noval framework successfully overcomes the limitation of the original model which was only able to consider two uncorrelated parameters, namely the cohesion and the internal friction angle. • This enhancement has significantly improved the generalizability of the FSLAM model.



(m/s)	n (-)	ρ <b>(kg/m³)</b>	HSG	LULC	<i>C<sub>r</sub>-min/max (kPa)</i>	CN-A (-)	СМ-В (-)	CN-C (-)	CN-D
2			(-)						(-)
(10 <sup>-3</sup>	0.3	2000	A	Forest	4/14	40	60	69	76
10 <sup>-6</sup>	0.3	2000	В	Shrubs	3/6	43	65	76	82
(10 <sup>-2</sup>	0.4	2000	Α	Grassland	2/1	10	69	70	8/
10 <sup>-5</sup>	0.3	2000	В	Glassiallu	2/4	49	09	19	04
10-5	0.25	2000	٨	Bare soil	0/0	77	86	91	94
. 10	0.35	2000	A	Scree	0/0	30	30	30	30
×10 <sup>-4</sup>	0.35	2000	A						
10 <sup>-6</sup>	0.3	2000	В	Weathered bedrock	0/0	77	86	91	94
10 <sup>-5</sup>	0.3	2000	Α	Intact bedrock	0/0	77	86	91	94
10 <sup>-5</sup>	0.3	2000	Α	Urban area	0/1	90	92	96	98
10 <sup>-6</sup>	0.3	2000	В	Water	999/999	100	100	100	100
10 <sup>-6</sup>	0.3	2000	В	Glacier-snow	999/999	100	100	100	100

### Simulations Results