







Integrating HAND Model and Soil Data for Flood Risk **Assessment in São Paulo:** Insights for the Insurance Sector

IRB(P&D)

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α-Flood IRB(P&D)







Differences

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Source: flood - Acqualis Water Engineering - Water Resources Consulting







α-Flood IRB(R&D) as it is used in everyday life



Automated reporting allows subscribers like Pedro to make decisions in minutes, not days.





output

flood risk analysis report for each location São Paulo 2025

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What can be seen in the report ?





Número de Contrat 0-10 11-50 51-100 101-500 501-1000

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Subscritor responsável: <u>EquipeIRC</u> Contrato n.º: Contrato1 Segurado original: XXX Data da análise: 25/09/2017

Modelo a-<u>Flood IRB(</u>P&D)

O modelo a-<u>Flood IRB(P&D)</u> avalia a susceptibilidade do terreno à inundação com base na altura em relação ao dreno mais próximo, conforme metodologias descritas nos artigos científicos listados ao final desse documento. Para facilitar sua interpretação e aplicação, os resultados do modelo são categorizados em cinco níveis, representando diferentes graus de susceptibilidade a inundações.

Modelo α-Flood IRB(P&D) para análise de a inundações em uma ou mais localidades

Categoria	Intervalo (m)	Cor no mapa	Descrição
C1	Om a 1m		Maior suscetibilidade de inundação, já que qualquer aumento no níve de água pode facilmente causar alagamentos.
C2	1m a 5m		Suscetibilidade elevada de inundação. Embora levemente elevadas, continuam próximas ao ponto de drenagem e são vulneráveis a inundações moderadas.
G	5m a 10m		Suscetibilidade intermediária. Essas áreas podem se inundar durante eventos de chuvas intensas, mas estão em uma elevação um pouco maior, proporcionando alguma proteção natural.
C4	10m a 25m		Baixa suscetibilidade de inundação. Com uma elevação considerável, essas regiões tendem a ser menos suscetíveis a alagamentos, exceto em condições extremas.
C5	25m a 100m		Menor suscetibilidade de inundação. Com elevações substancialmente acima dos pontos de drenagem, essas áreas têm uma proteção natural contra a maioria dos eventos de inundação.

Category Elevation Range (m) Map Color Description Highest flood susceptibility, as any C1 0m to 1m increase in water level can easily cause flooding. High flood susceptibility. Although slightly elevated, these areas remain close to 1m to 5m C2 drainage points and are vulnerable to moderate flooding. Intermediate susceptibility. These areas may flood during heavy rainfall events but **C**3 5m to 10m are slightly higher, offering some natural protection. Low flood susceptibility. With considerable C4 elevation, these areas are less likely to 10m to 25m flood, except under extreme conditions. Lowest flood susceptibility. With elevations substantially above drainage points, these C5 25m to 100m areas have natural protection against most flood events.





Flood risk analysis report for each location



Categoria de classificação <u>HAND</u>: Alto (1-5m) Latitude: <u>-23.6295</u> Longitude: <u>-46.8203</u> Endereço: Av. Hélio <u>Ossamu Daikuara</u>, n. 198 - Moinho Velho - Embu das Artes/SP - <u>CDEM</u> DM: R\$ 131.445.782,72 LC: R\$ 0,00 <u>TIV</u>: R\$ 131.445.782,72

Categoria	Qtde Loc.	% Loc.	DM (R\$ mil)	LC (R\$ mil)	TIV (R\$ mil)	% DM	DM Acum (R\$ mil)	%_DM Acum
C1	16	4.66	127.236	0	127.236	4.18	127.236	4.18
C2	52	15.16	620.963	0	620.963	20.42	748.199	24.61
C3	73	21.28	582.569	0	582.569	19.16	1.330.768	43.76
<u>C4</u>	100	29.15	804.934	0	804.934	26.47	2.135.702	70.24
C5	99	28.86	901.690	0	901.690	29.65	3.037.392	99.89
NL	3	0.87	3.358	0	3.358	0.11	3.040.750	100.0
TOTAL	343	100,0	3.041	0	3.040.750	100,0	3.040.750	





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HAND – Height Above Nearest Drainage

Height Above Nearest Drainage - HAND

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Flowchart of the steps required to create the HAND raster. (a) Corrected DEM (b) Flow direction (c) Accumulation flow, and (d) Raster with height above nearest drainage HAND



HAND (Height Above Nearest Drainage):

- point.
- meters above the nearest river/stream.

Importance for the Insurance Sector:

- mitigation.
- zones in urban areas).



5

6

5

8



(Nobre et al. 2011)

• Measures the elevation of terrain (in meters) above the nearest drainage

• **Example**: If an area has a HAND of **5 meters**, it means the location is 5

Risk Identification: Areas with low HAND (e.g., 0–7m) are prioritized for

Loss Prevention: Helps avoid claims in critical locations (e.g., industrial



HAND Mapping Explanation for São Paulo city











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HAND – Height Above Nearest Drainage



Case Study Porto Alegre Rio Grande do Sul 2024



New York Times, Clarín, BBC: tragédia no RS repercute em todo o mundo

Do UOL, em São Paulo 05/05/2024 15h46

() lin



Vista aérea de ruas alagadas do bairro Navegantes, em Porto Alegre (RS) Imagem: Carlos Fabal/AFP

A imprensa internacional tem repercutido a tragédia climática no Rio Grande do Sul, que deixou ao menos 75 mortos e 103 desaparecidos até o começo da tarde deste domingo (5). Veículos como o The New

Brazil floods: Hundreds of Rio Grande do Sul towns under water

7 May 2024

Vanessa Buschschlüter



Watch: Images show devastating impact of Brazil floods

At least 85 people died in the floods and about 150,000 have been displaced from their homes, officials said.



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Heavy rains which caused widespread flooding in the southern Brazilian state of Rio Grande do Sul have left hundreds of towns under water.





São Paulo 2025

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C4

C5

Elevation Range (m)	Map Color	Description
0m to 1m		Highest flood susceptibility, as any increase in water level can easily cause flooding.
1m to 5m		High flood susceptibility. Although slightly elevated, these areas remain close to drainage points and are vulnerable to moderate flooding.
5m to 10m		Intermediate susceptibility. These areas may flood during heavy rainfall events but are slightly higher, offering some natural protection.
10m to 25m		Low flood susceptibility. With considerable elevation, these areas are less likely to flood, except under extreme conditions.
25m to 100m		Lowest flood susceptibility. With elevations substantially above drainage points, these areas have natural protection against most flood events.



Practical validation

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Map with α-Flood IRB(P&D) classification and history of occurrences in SP (2010-2023)









Bar chart with α -Flood IRB(R&D) classification in the historical occurrences in SP





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Model α-Flood IRB(P&D)





HAND – Height Above Nearest Drainage

> Frequency of Occurrence of Flood Events

> > Soil Type and Land Use



Soil Type and Land Use

	High	Medium	Low	۱	/ery Low	Extremely Low
(cm/s)	10 ² - 10 ⁰	10º - 10-2	10-2 - 10-4	1	0-4 - 10-6	10-6 - 10-8
Material	Gravel	Sand	Very fine sands, silt, or mixt	ures Silt-o	lay mixtures	Clays
	Santana de Parnalba		Guaru	hos It	quaquecetuba	
	Itapevi	Osasco	São Paulo		Suzano	Mi
	Cotia	Taboão da Serra		AN C		
	Z Emburg	las Artes	Santo A	ndré		
	Itape	ecerica	São Berna do Camp	SOIL TYPE	SOIL PERMEABILI (cm/s)	тү
	da.	Serra	Alle XHIX	// Urban Area	$0 \text{ to } 10^{-5}$	
	4	an	Vinter of the	Cambisol	10^{-3} to 10^{-4}	
		Ser Y	Proteção Billing	Acrisol	10^{-6} to 10^{-7}	
	São Lourenço	Embu-Guaçu	do Borore- Colónia SP-160	Ferralsol	10^{-10} to 10^{-11}	
		and the second sec				











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HAND – Height Above Nearest Drainage

> Frequency of Occurrence of Flood Events

> > Soil Type and Land Use

Insurance claims history in the location



Validation with real insurance contracts

	C5 (m. baixo)	C4 (baixo)	C3 (médio)	C2 (alto)	(
contract 5				100%	100%
contract 3	25%	23%	18%	27%	34%
contract 2	25%	30%	22%	21%	23%
24-5-11-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-11-12-1	20%	27%	1004	20%	240/
contract 1	30%	2170	1970	20%	24%
contract 4	33%	32%	20%	13%	15%
contract 6	55%	27%	4%	12%	14%

Category	Elevation Range (m)	Map Color	Descrip
C1	0m to 1m		Highest flood susceptib increase in water level of flooding.
C2	1m to 5m		High flood susceptibility elevated, these areas re drainage points and are moderate flooding.
C3	5m to 10m		Intermediate susceptibi may flood during heavy are slightly higher, offer protection.
C4	10m to 25m		Low flood susceptibility. elevation, these areas a flood, except under extr
C 5	25m to 100m		Lowest flood susceptibi substantially above drai areas have natural prot flood events.







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 With considerable are less likely to reme conditions.
With elevations inage points, these tection against most





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Next steps

Al Agent Integration for Automated Inspection Summaries

Incorporation of hydrological models

History of extreme precipitation by location

Model α-Flood IRB(P&D)





HAND – Height Above Nearest Drainage

> Frequency of Occurrence of Flood Events

> > Soil Type and Land Use

Insurance claims history in the location

References

Nobre AD, Cuartas LA, Hodnett M, Rennó CD, Rodrigues G, Silveira A, Saleska S (2011) Height Above the Nearest Drainage-a hydrologically relevant new terrain model. J Hydrol 404(1-2):13-29. https:// doi.org/10.1016/j.jhydrol.2011.03.051

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Height Above the Nearest Drainage a hydrologically relevant new terrain model

Nobre_et_al-2015-Hydrological_Processes-libre.pdf

HAND Model – A new look over the landscape





Thank you! Obrigado! Questions?



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