PROSPECTING POTENTIAL GROUNDWATER ZONES THROUGH GEOTECHNOLOGY AND STATISTICAL TECHNIQUES IN THE GRANDE RIVER BASIN, BAHIA , BRAZIL.

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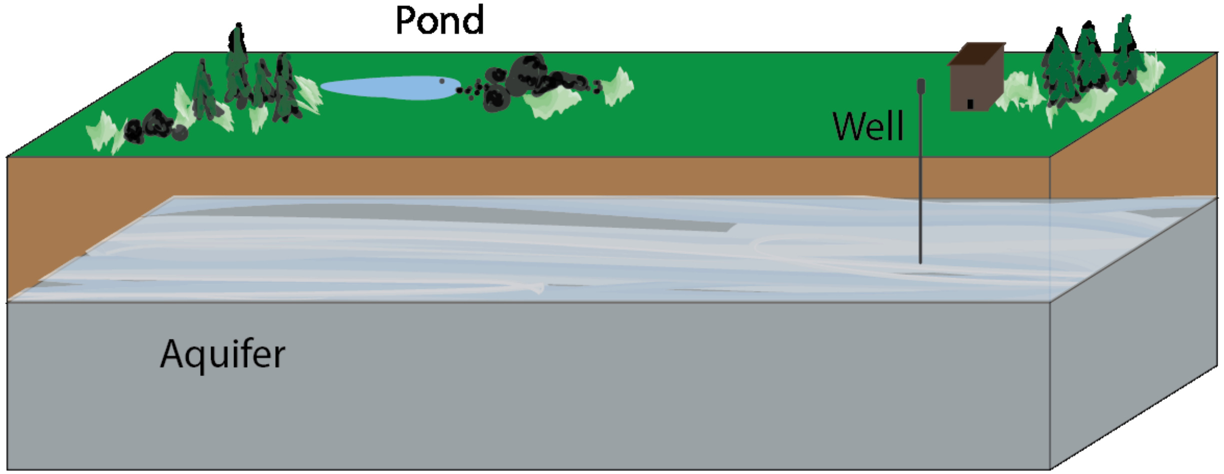
OVERVIEW

Motivations of the Study

- Semi-arid area
- Limited Resources
- Drougth
- Population
- Important Agricultural
- Dependent of Groundwater
- Localize in Importants Hidrogeological
- Groundwater is a valuable and important natural resource



Ariel Zych, Ryan Hollister, Xochitl Garcia; 2018

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OVERVIEW

Goals :

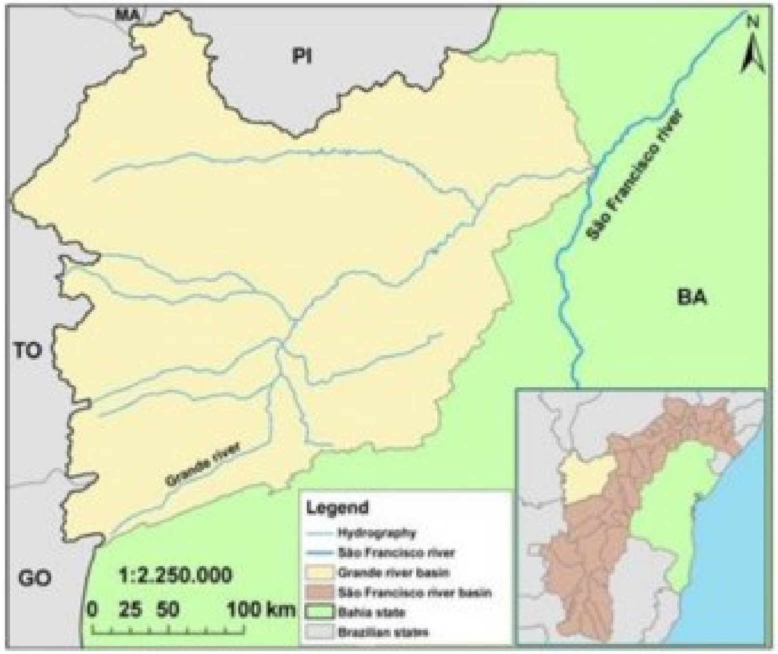
1. Integrate methodologies (GIS, Remote Sensing and Statistic)
2. Analyze variables (8) and reclassify them according to their hierarchy
3. Identify the factors that most affect groundwater potential
4. Assess, and delineate the groundwater potential
5. Validate the model with statistical

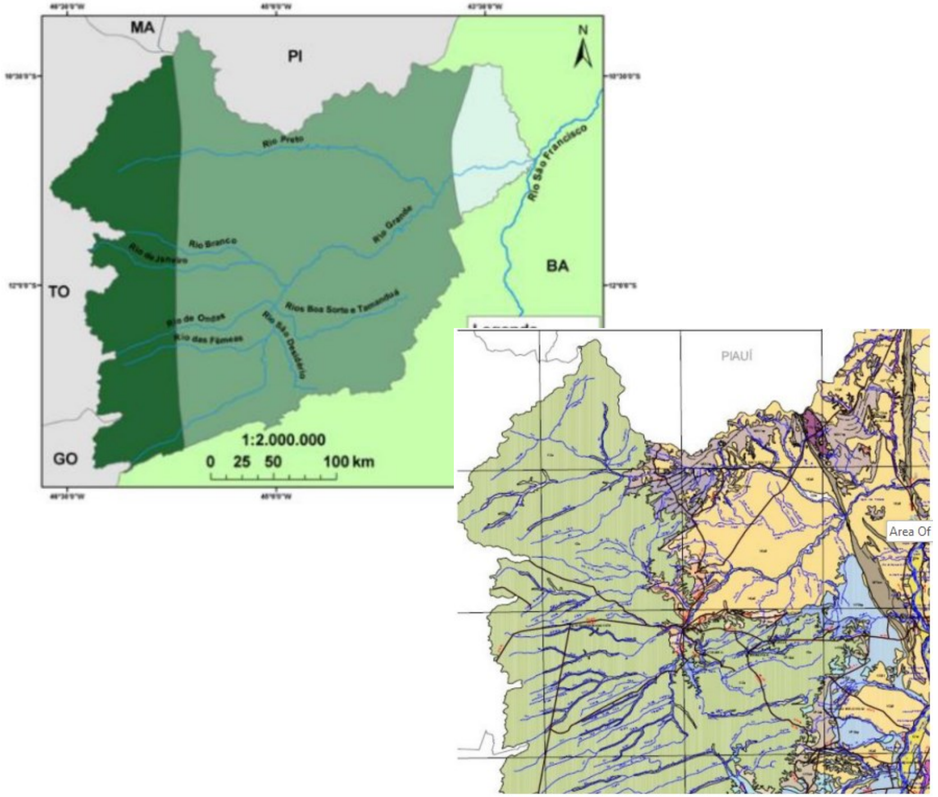
OVERVIEW

Methods :

- Thematic Maps
- Reclassify
- Comparison of criteria and weight with Analytical Hierarchy Process (AHP)
- Validation is done by considering the locations of the groundwater wells in the data sets, overlaying it on the result, analyzing its density and the statistical probability of the existence of groundwater.
- Numerical-spatial correlation between wells and potential areas through Moran's Index (P-Value and Zscore)
- The receiver operating characteristic curve (ROC) and area under the curve (AUC) analysis were used to explore the accuracy of the model.

AREA OF STUDY





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DATASET

- The lithology, soil, hydrogeology data sets are acquired from different online sources, Geological Service of Brazil (CPRM), Brazilian Enterprise of Agriculture and Livestock a (EMBRAPA).
- The satellite images that will compose the study will be the Landsat 8, with 30x30m resolution, where it will be used to generate the Lineament Density layer, and the land use and occupation. The Shuttle Radar Topography Mission (SRTM), with 30 m resolution, will be used to develop information on the drainage and slope layers.
- The point data of mean monthly precipitation quadratic was acquired from the National Institute of Meteorology (INMET) and used to develop the rainfall layer. The well data for method validation, will be sourced from the Groundwater Information System (SIAGAS), Water Resources Superintendence of Bahia (SRH), National Water Agency (ANA), Institute of Environment and Water Resources (INEMA), Water User Registry (CNRH), Hydric Energy and Basic Sanitation Company (CERB), Geological Service of Brazil (CPRM)

RECLASS DATAS FOR AHP

Index Value	Class
1	Very Low
2	Low
3	Moderate
4	Higth
5	Very Higth

The first step was data acquisition processing, the second step consisted of reclassification. (Litology, Soils, Density Drain, Density of Lines, Rainfall, Slope, Elevation , Land Use)

It is noteworthy that to perform the analysis it is necessary that the data sets have the same number of classes. That is, it is necessary to establish intervals between the existing values for each indicator.

The AHP proposed by Saaty determines the degree of probability according to the correlation of each variable among themselves, through the overlay of variables, each variable analyzed has differentiated values that, after indexed, compose the degree of probability.

Based on the result obtained one can classify the degree of probability of occurrence of the potential areas of groundwater (Very High, High, Moderate, Low and Very Low).

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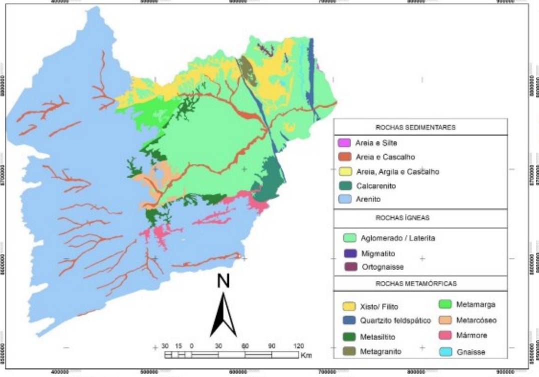
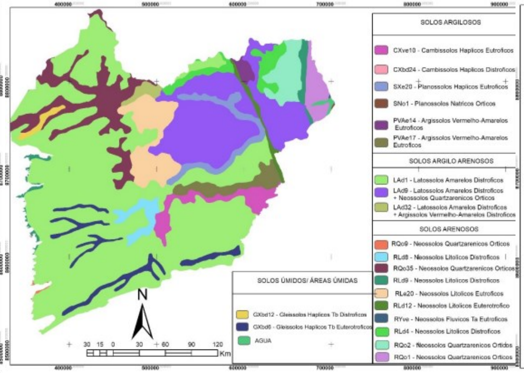
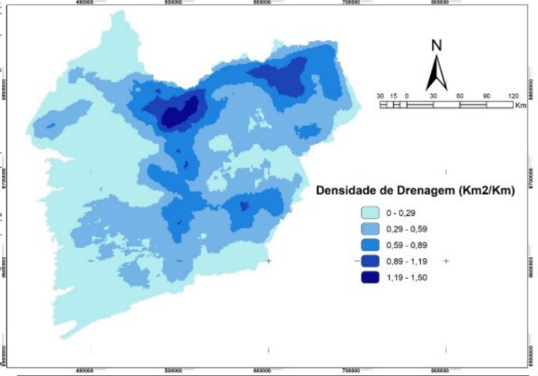
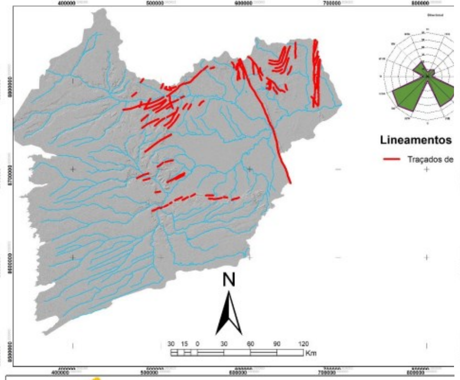
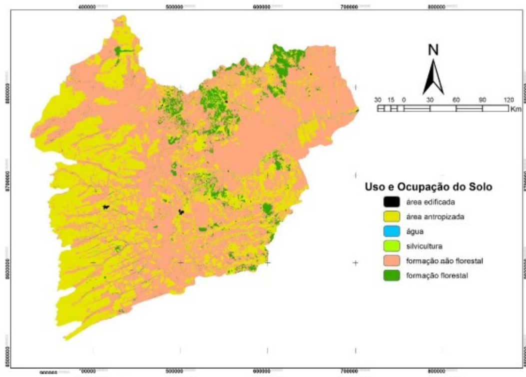
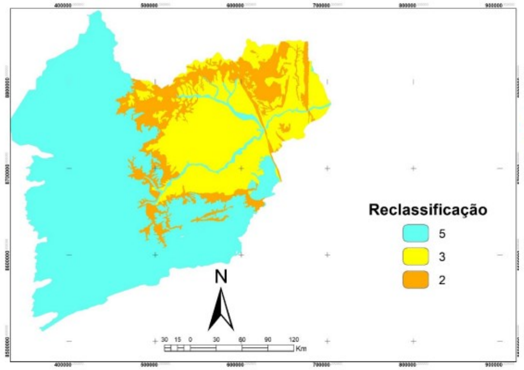

ROCHAS SEDIMENTARES
Areia e Silte
Areia e Cascalho
Areia, Argila e Cascalho
Calcarenito
Arenito
ROCHAS ÍGNEAS
Aglomerado / Laterita
Migmatito
Ortognaisse
ROCHAS METAMÓRFICAS
Xisto/ Filito
Quartzito feldspático
Metasiltito
Metagranito
Metamarga
Metarcóseo
Mármore
Gnaisse
N
Km

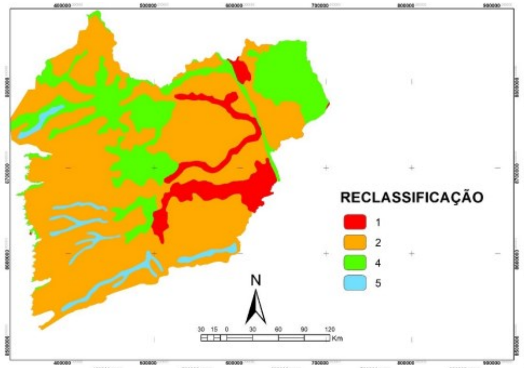

SOLOS ARGILOSOS
CXve10 - Cambissolos Haplicos Eutroficos
CXbd24 - Cambissolos Haplicos Distroficos
SXe20 - Planossolos Haplicos Eutroficos
SNo1 - Planossolos Natricos Orticos
PVAe14 - Argissolos Vermelho-Amarelos Eutroficos
PVAe17 - Argissolos Vermelho-Amarelos Eutroficos
SOLOS ARGILO ARENOSOS
LAd1 - Latossolos Amarelos Distroficos
LAd9 - Latossolos Amarelos Distroficos + Neossolos Quartzarenicos Orticos
LAd32 - Latossolos Amarelos Distroficos + Argissolos Vermelho-Amarelos Distroficos
SOLOS ARENOSOS
RQo9 - Neossolos Quartzarenicos Orticos
RLd8 - Neossolos Litolicos Distroficos
RQo35 - Neossolos Quartzarenicos Orticos
RLd9 - Neossolos Litolicos Distroficos
RLe20 - Neossolos Litolicos Eutroficos
RLd12 - Neossolos Litolicos Eutrotroficos
RYve - Neossolos Fluvicos Ta Eutroficos
RLd4 - Neossolos Litolicos Distroficos
RQo2 - Neossolos Quartzarenicos Orticos
RQo1 - Neossolos Quartzarenicos Orticos
SOLOS ÚMIDOS/ ÁREAS ÚMIDAS
GXbd12 - Gleissolos Haplicos Tb Distroficos
GXbd6 - Gleissolos Haplicos Tb Eutroficos
ÁGUA
N
Km

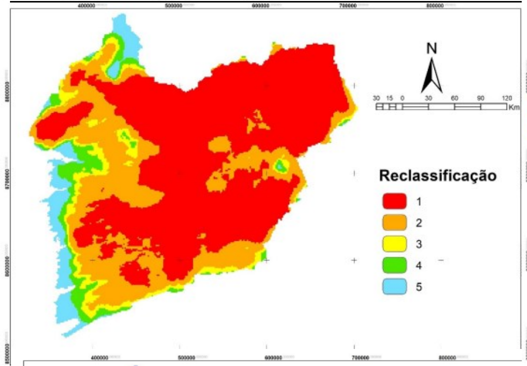

N
Km
Densidade de Drenagem (Km2/Km)
0 - 0,29
0,29 - 0,59
0,59 - 0,89
0,89 - 1,19
1,19 - 1,50

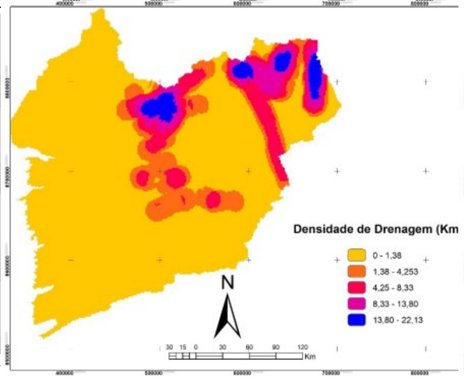

Lineamentos
Traçados de
N
Km

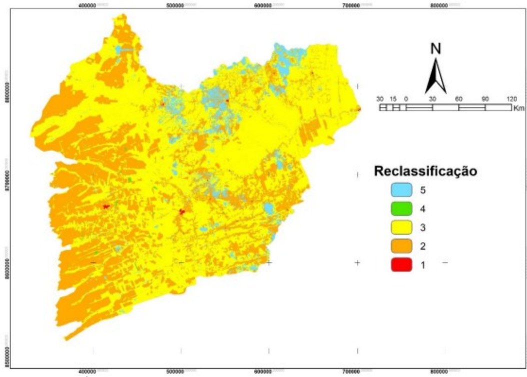

N
Km
Uso e Ocupação do Solo
área edificada
área antropizada
água
silvicultura
formação não florestal
formação florestal

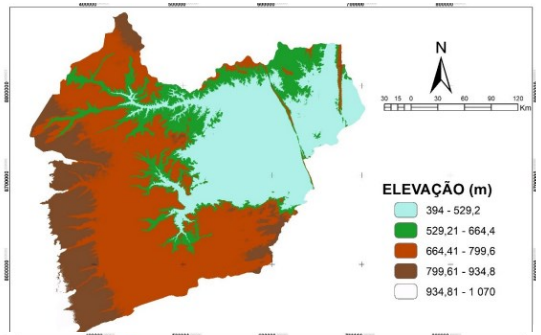

Reclassificação
5
3
2
N
Km

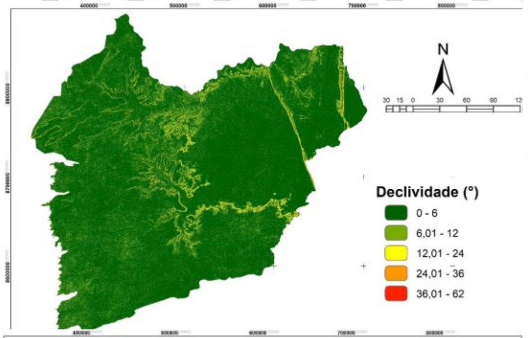

RECLASSIFICAÇÃO
1
2
4
5
N
Km

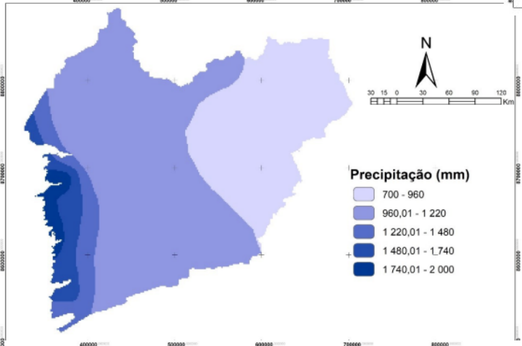

N
Km
Reclassificação
1
2
3
4
5

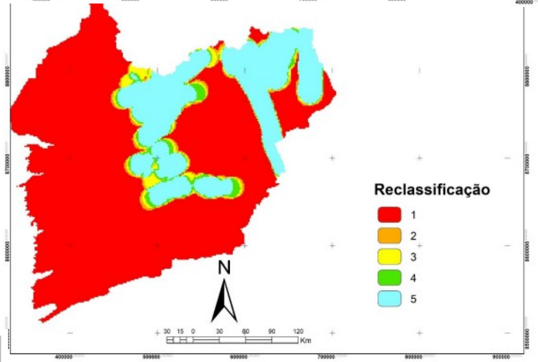

Densidade de Drenagem (Km
0 - 1,38
1,38 - 4,253
4,25 - 8,33
8,33 - 13,80
13,80 - 22,13
N
Km

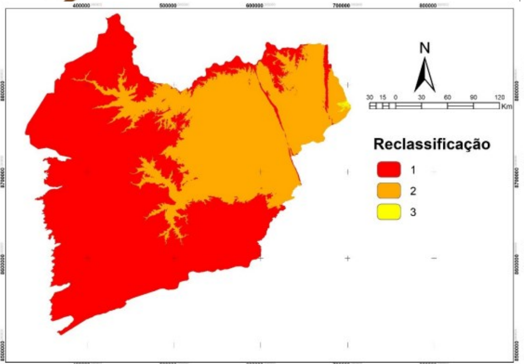

N
Km
Reclassificação
5
4
3
2
1

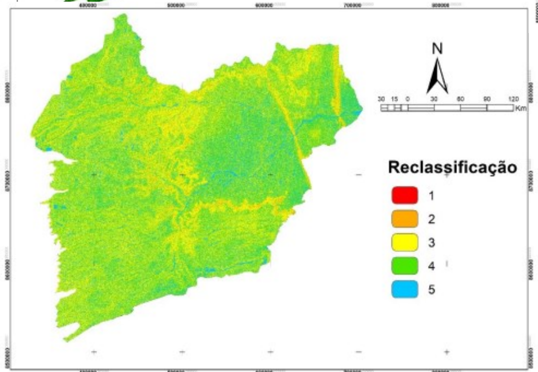

N
Km
ELEVAÇÃO (m)
394 - 529,2
529,21 - 664,4
664,41 - 799,6
799,61 - 934,8
934,81 - 1 070

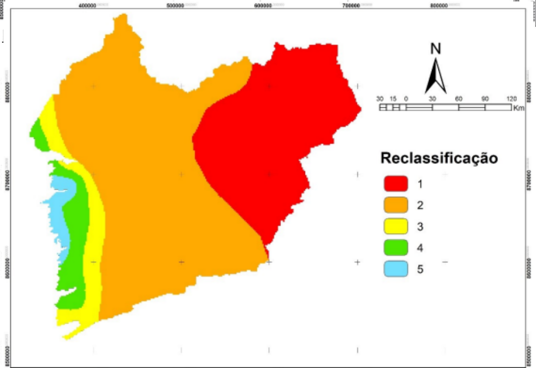

N
Declividade (°)
0 - 6
6,01 - 12
12,01 - 24
24,01 - 36
36,01 - 62


N
Km
Precipitação (mm)
700 - 960
960,01 - 1 220
1 220,01 - 1 480
1 480,01 - 1 740
1 740,01 - 2 000


Reclassificação
1
2
3
4
5
N
Km


N
Km
Reclassificação
1
2
3


N
Km
Reclassificação
1
2
3
4
5


N
Km
Reclassificação
1
2
3
4
5

MATRIX AHP/ NORMALIZATION

Matrix AHP – Saaty

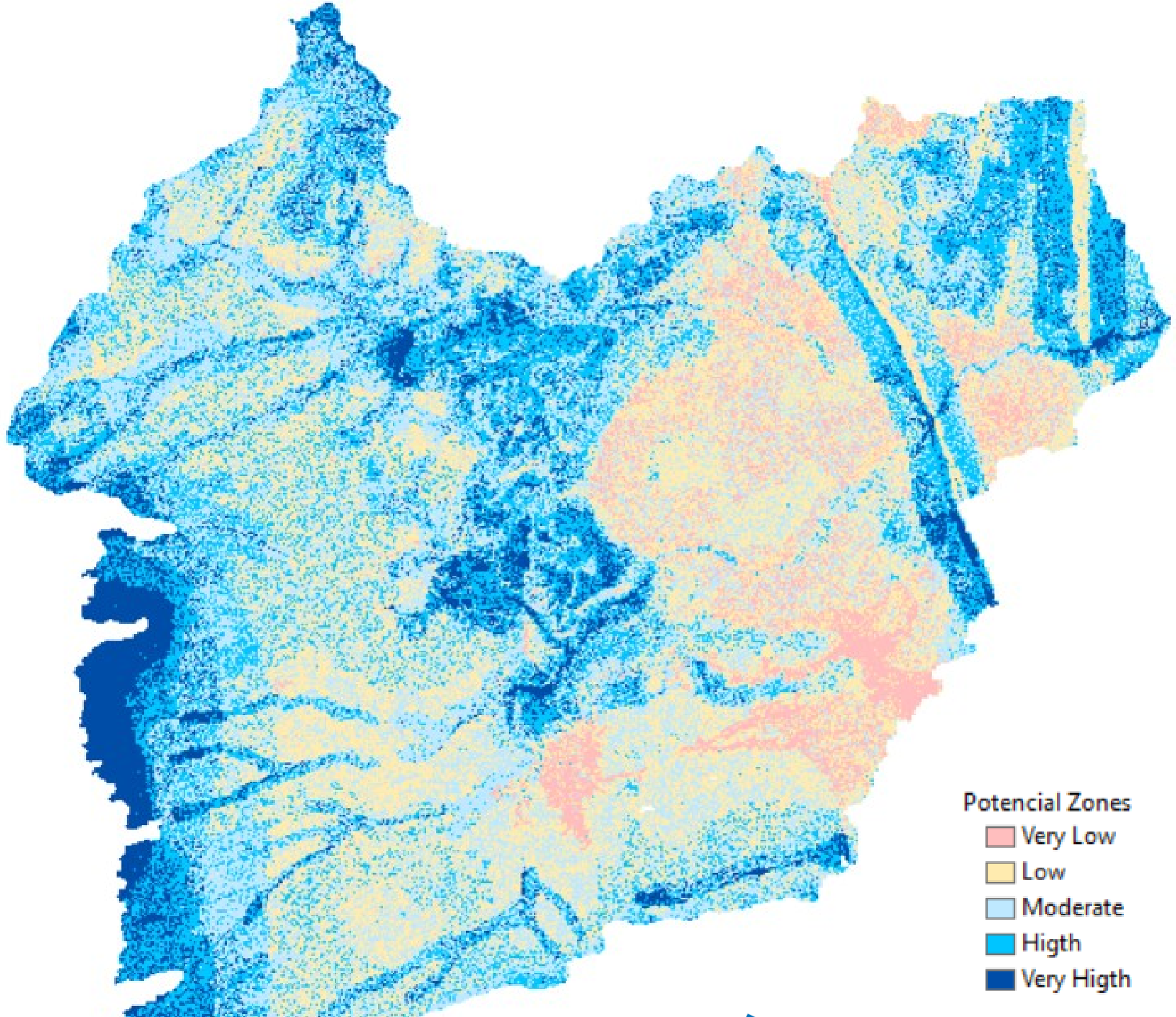
FATORES	Elevação	Declividade	Litologia	Solos	Precipitação	Densidade de Drenagem	Densidade de Lineamento	Uso e Ocupação do Solo
Elevação	1,00	2,00	3,00	3,00	2,00	2,00	2,00	3,00
Declividade	0,50	1,00	2,00	2,00	1,00	2,00	2,00	2,00
Litologia	0,33	0,50	1,00	2,00	1,00	2,00	2,00	2,00
Solos	0,33	0,50	0,50	1,00	1,00	2,00	2,00	2,00
Precipitação	0,50	1,00	1,00	1,00	1,00	3,00	3,00	3,00
Densidade de Drenagem	0,50	0,50	0,50	0,50	0,33	1,00	1,00	2,00
Densidade de Lineamento	0,50	0,50	0,50	0,50	0,33	1,00	1,00	2,00
Uso e Ocupação do Solo	0,33	0,50	0,50	0,50	0,33	0,50	0,50	1,00

Translation :
Elevação = Elevation
Declividade = Slope
Litologia = Litology
Solos = Soils
Precipitação = Rainfall
Densidade Drenagem = Drain Density
Densidade de Lineamento = Line Density
Uso e Ocupação do Solo = Land Use

NORMALIZATION

Elevação	0,25	0,3077	0,3333	0,2857	0,2857	0,1481	0,1481	0,1765	24%
Declividade	0,125	0,1538	0,2222	0,1905	0,1429	0,1481	0,1481	0,1176	16%
Litologia	0,0833	0,0769	0,1111	0,1905	0,1429	0,1481	0,1481	0,1176	13%
Solos	0,0833	0,0769	0,0556	0,0952	0,1429	0,1481	0,1481	0,1176	11%
Precipitação	0,125	0,1538	0,1111	0,0952	0,1429	0,2222	0,2222	0,1765	16%
Densidade de Drenagem	0,125	0,0769	0,0556	0,0476	0,0476	0,0741	0,0741	0,1176	8%
Densidade de Lineamento	0,125	0,0769	0,0556	0,0476	0,0476	0,0741	0,0741	0,1176	8%
Uso e Ocupação do Solo	0,0833	0,0769	0,0556	0,0476	0,0476	0,037	0,037	0,0588	6%

GROUNDWATER POTENCIAL ZONES

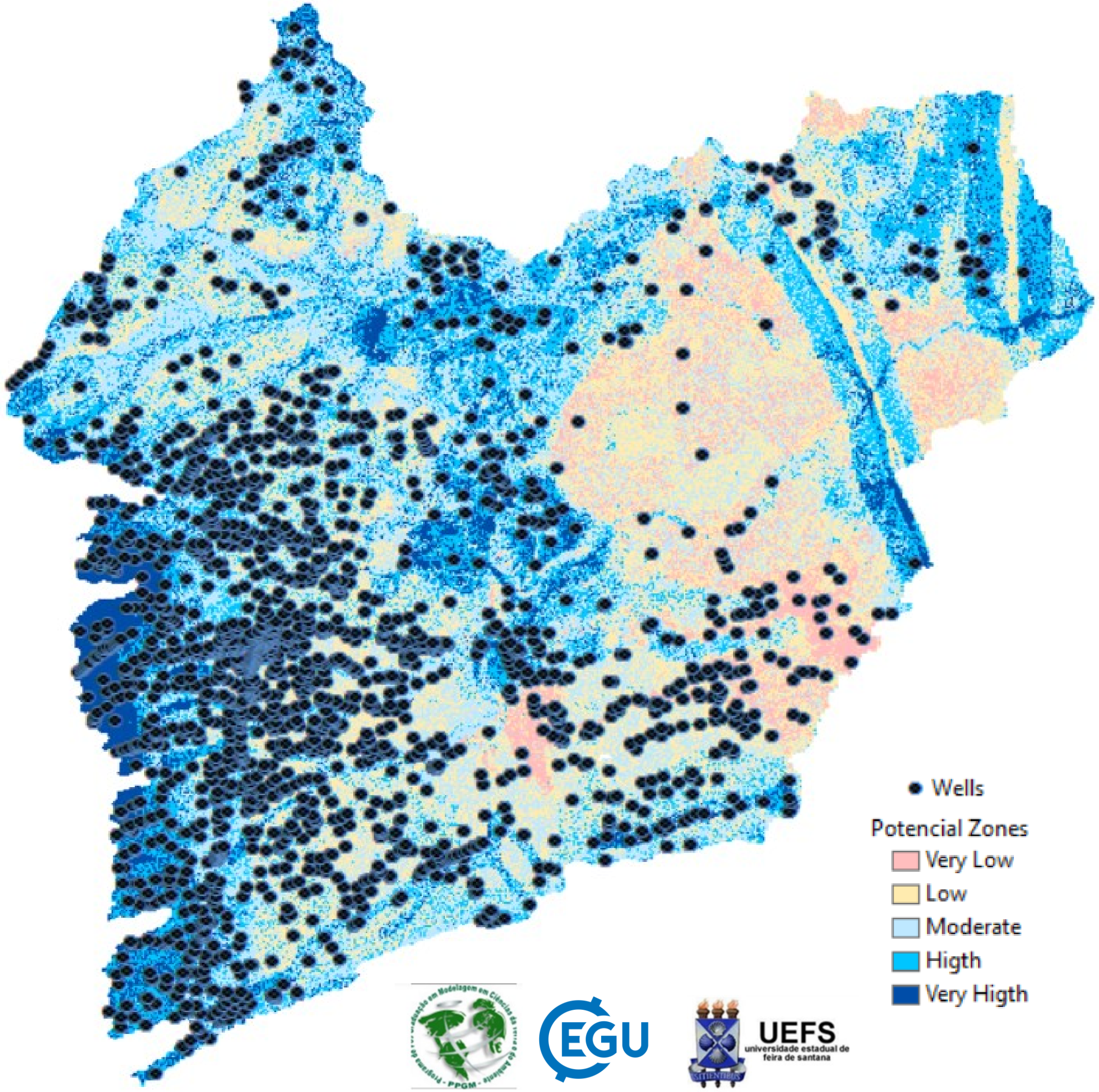


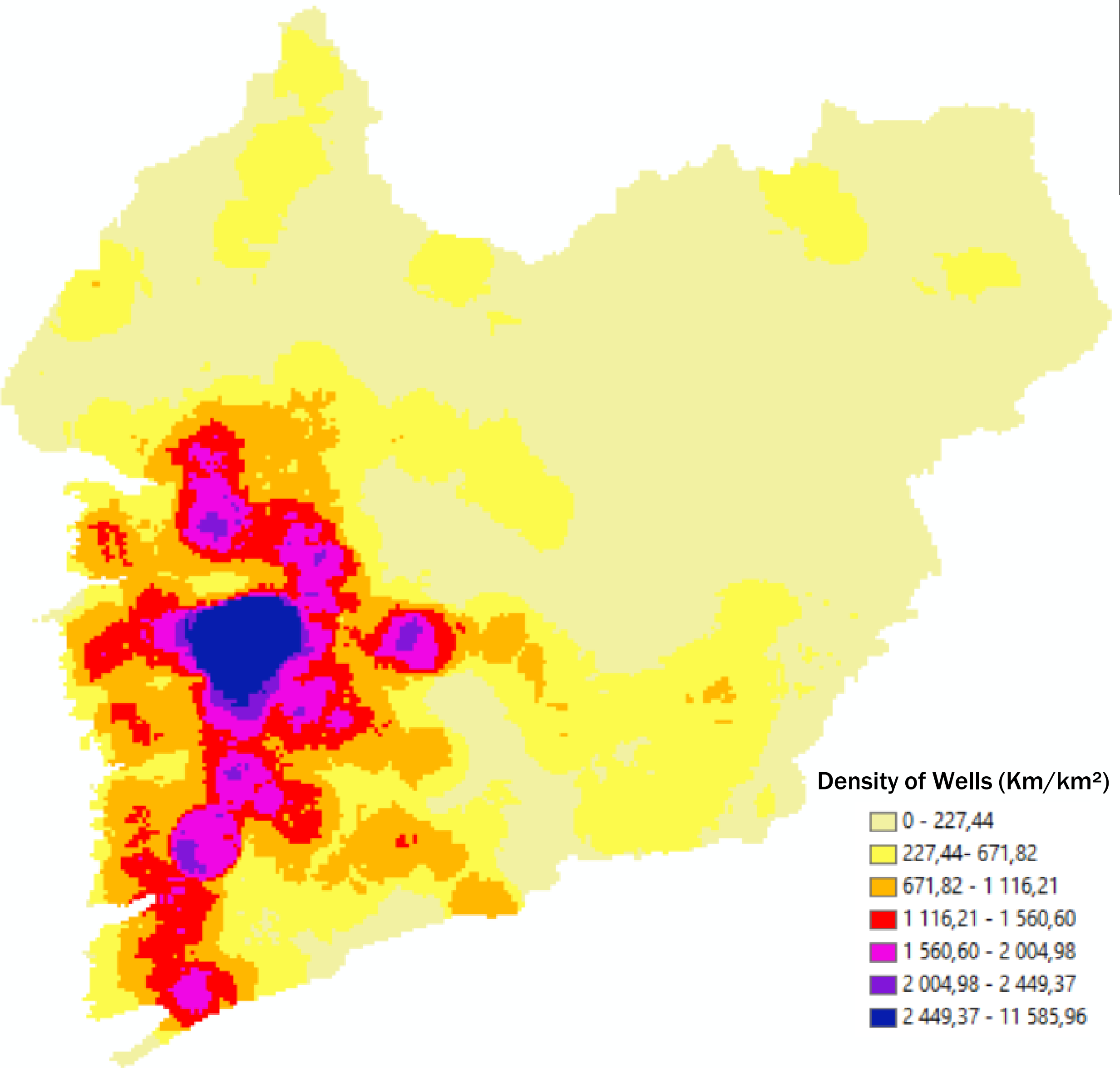
GWPZM = 24 * EL + 16 * DCL + 13* LIT + 11 * SOL + 16 * PREC + 8 * DD + 8* DL + 6 * USC

EL = Elevation DD = Drain Density
DCL = Slope DL = Line Density
LIT = Litology
SOL= Soils
PREC = Rainfall
USC = Land Use

Potencial Class	Area (km²)
Very Low	502,06
Low	3599,28
Moderate	20798,11
Higth	35241,37
Very Higth	15570,14

VALIDATION- WELLS DENSITY





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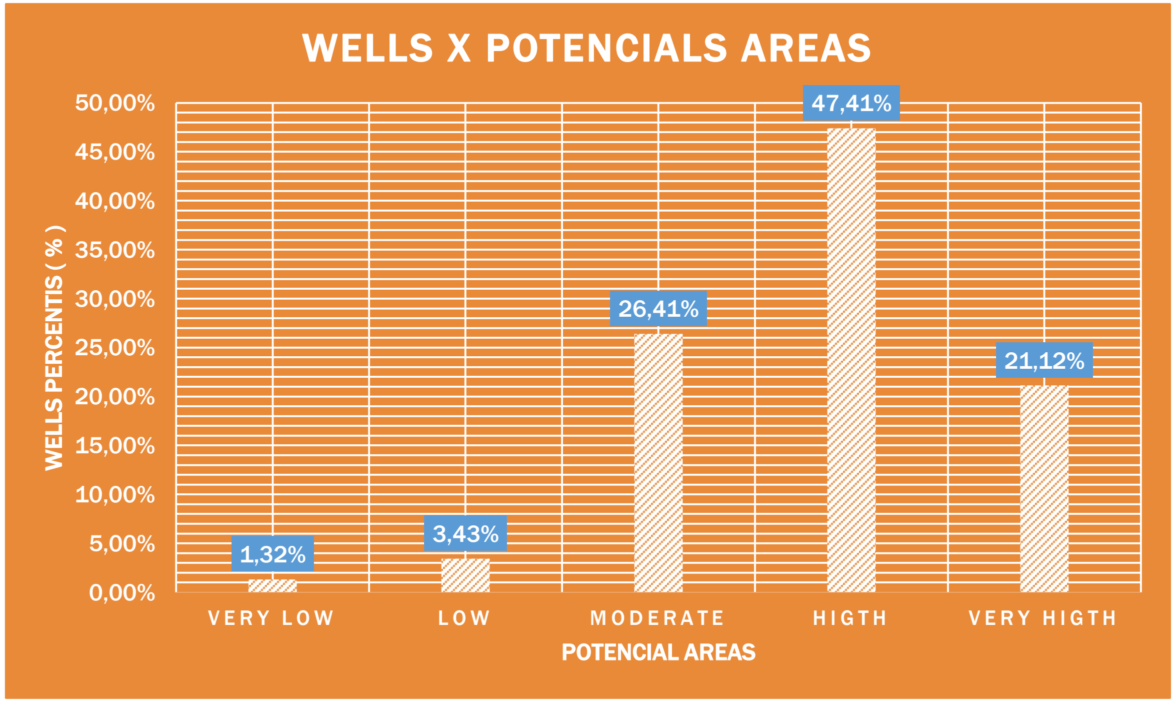
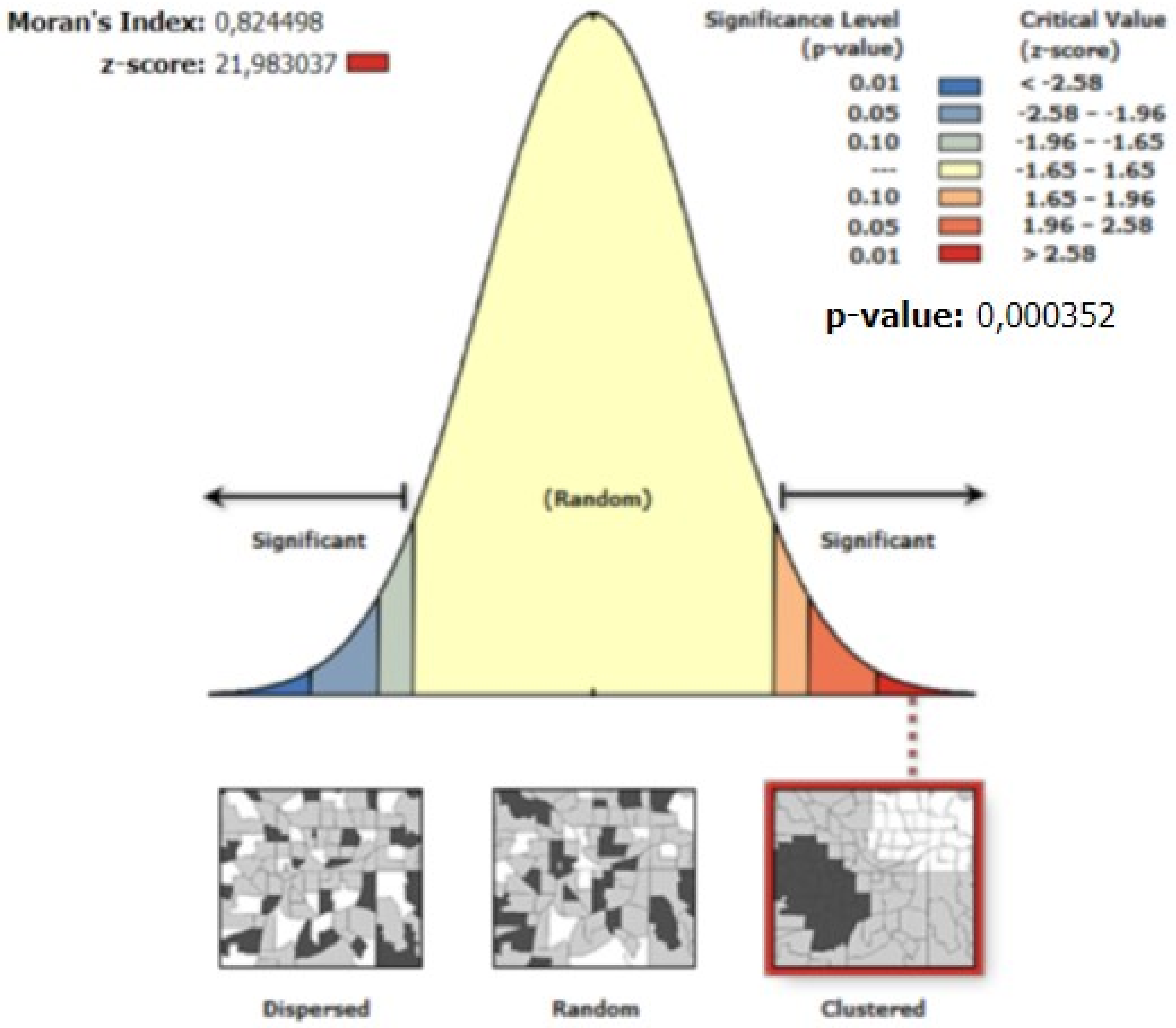
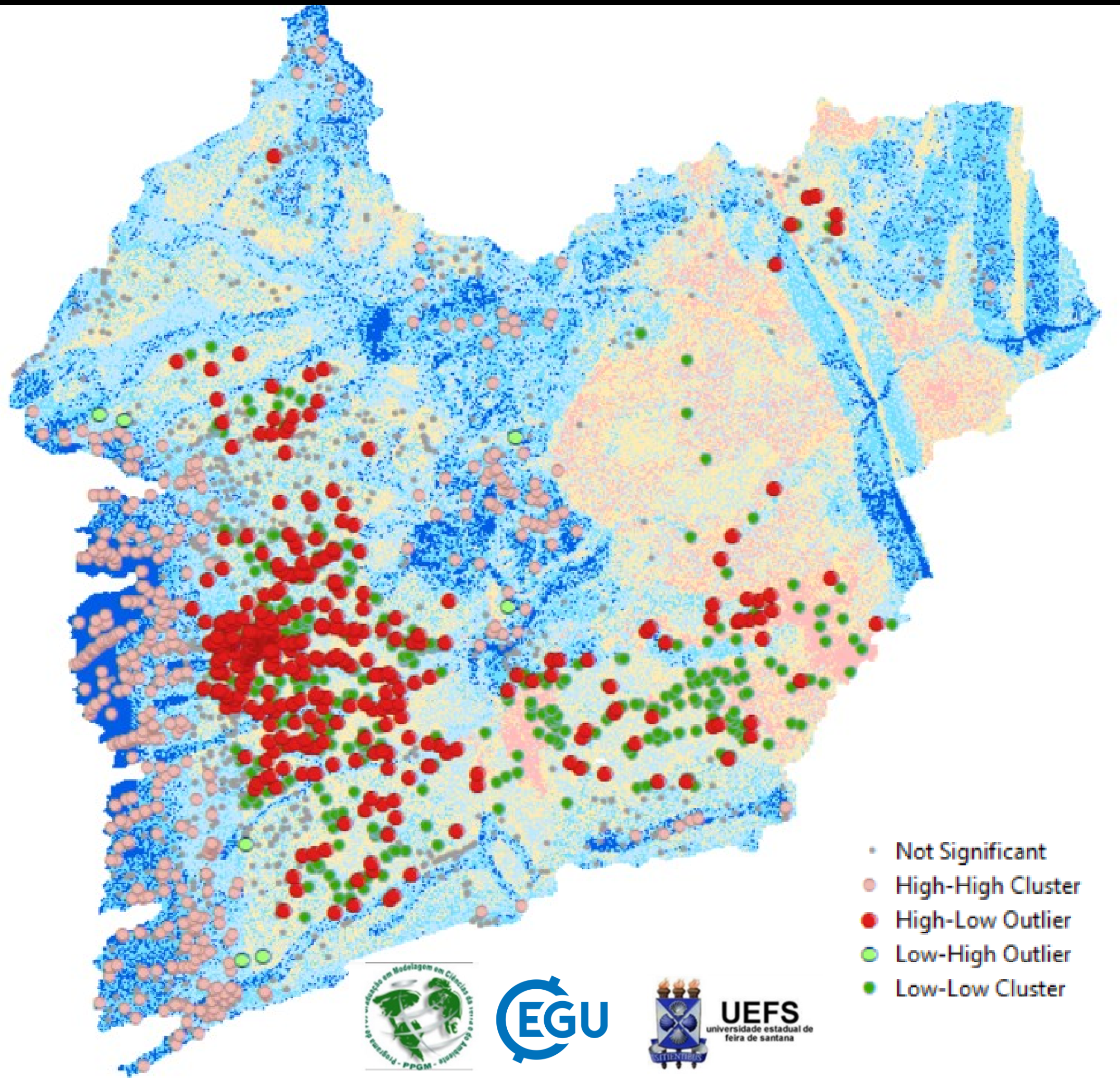
VALIDATION - WELLS STATISTIC OVERLAY

Potencial Zones	N° of Wells
Very Low	10
Low	42
Moderate	1000
Higth	1807
Very Higth	289



VALIDATION – MORAN INDEX





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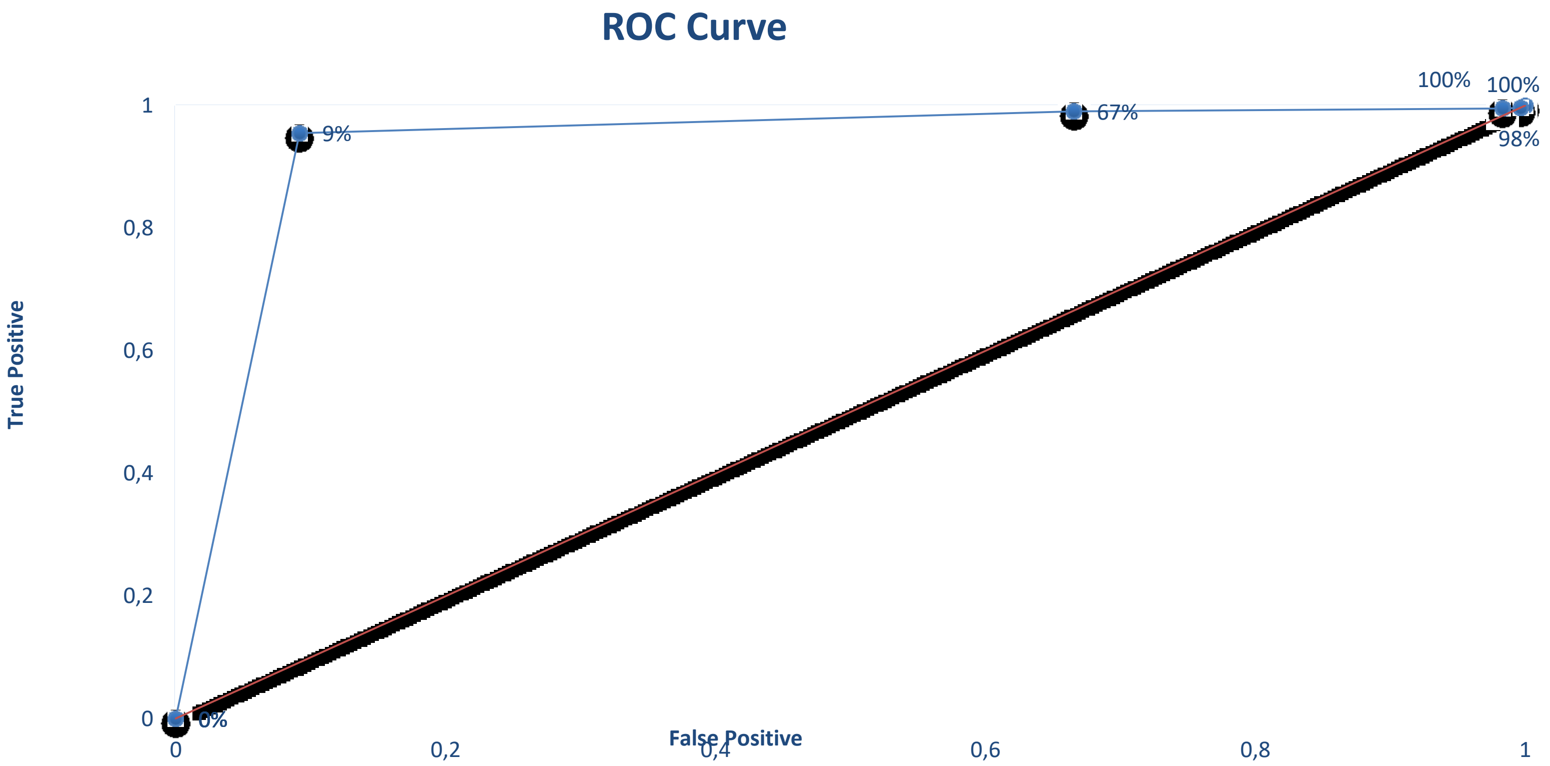
VALIDATION – CURVE ROC

Cut Points:	Normal Cases	Non-Normal Cases
1	10	9,571428571
2	42	3,421
3	1000	11,21638074
4	1807	90,43944637
5	289	2445
	3148	2559,648256
Area Under the Curve		,9341
Stderr		,0036
Confidence Interval	,927	,941
Accuracy of Test		Excellent



CONCLUSION

- The hydrogeological potential in the River Grande Basin apparently presents potential heterogeneities of the different from the values, generated from the permeability characteristics of the rocks and the physical aspects that allow the infiltration of the precipitated water to the underground reservoirs.

- The Model has zones of potencial with correlation of wells, its is true if we look to numbers of wells in Higth and Very Higths zones, mores 68%, and more 26% in moderate zones, a total of 94% in good zones

- The Wells has a spacialcorrelation with zones potencial wells, with a concentration behavior, with Moran Index of 82 % conection bettwen zones and wells, with low P-Value and Higth Z-score, so a good beahvior.

- The Roc Curve has a good behavior, with AUC of 93% and confidence interval of 92% .

- The model is reliable because it has a high concentration of wells in potential zones, these wells have a strong positive correlation with these zones, creating specific zones of concentration. With a confidence index confirmed by roc analysis.

REF.

Annesh E Paresh. High Resolution Groundwater Prospect Mapping of Raichur, Karnataka Using Remote Sensing and GIS. Imperial Journal of Interdisciplinary Research, 2(8). Applicability of generalized additive model in groundwater potential modelling and comparison its performance by bivariate statistical methods. 2015

ANA – Agência Nacional de Águas – Hidrogeologia Básica, in Oficina de Capacitação de PROGESTÃO águas subterrâneas, Brasília, DF, 2016

ANA - Agência Nacional de Águas. Mapa Esquemático do Sistema Aquífero Guarani. Elaborado pela CAS/SRH/MMA (Coordenação de Águas Subterrâneas/Secretaria de Recursos Hídricos/ Ministério de Meio Ambiente) (UNPP - Unidade Nacional de Preparação do Projeto/Brasil). Escala 1:13.600.000. Brasília: Agência Nacional de Águas, 2001.

Andualem, T.G., Demeke, G.G. Groundwater potential assessment using GIS and remote sensing: a case study of Gunatana landscape, upper blue Nile Basin. Ethiopia J. Hydrol.: Reg. Stud. 24, 100610 ; 2019

Arabameri, A., Rezaei, K., Cerda, A., Lombardo, L., Rodrigo-Comino, J. GIS-based groundwater potential mapping in Shahroud plain, Iran. A comparison among statistical (bivariate and multivariate), data mining and MCDM approaches. Sci. Total Environ. 658, 160–177; 2019

Arkoprovo B, Adarsa J, Shashi Prakash S. Delineation of groundwater potential zones using satellite remote sensing and geographic information techniques: a case study from Ganjam district, Orissa, India. Res J Recent Sci 9:59–66; 2012

Arnold, W.S., White, M.W., Norris, H.A & Berrigan, M.E. Hard clam (Mercenaria spp.) aquaculture in Florida, USA: Geographic information system applications to lease site selection. Aquacultural Engineering 23, 203–231.2000

Avinash, K., Jayappa, K.S. and Deepika, B. Prioritisation of sub-basins based on

geomorphology and morphometric analysis using remote sensing and geographical information system (GIS) techniques. Geocarto International, vol. 26(7), pp. 569–592. 2011.

Barik K.K., Dalai P.C., Goudo S.P, Panda S., Nandi D. Delineation of Groundwater Potential Zone in Baliguda Block of Kandhamal District, Odisha using Geospatial Technology Approach Int. J. Adv. Remote Sens. GIS, 6, 2068; 2017

Bera K, Bandyopadhyay J. Groundwater potential mapping in Dulung watershed using remote sensing and GIS techniques, West Bengal, India. Int J Sci Res Publ 2(12):1–7; 2012

Borghetti, N. R. B.; Borghetti, J. R.; Rosa Filho, E. F. Aquífero Guarani: a verdadeira integração dos países do MERCOSUL. Cu ritiba: Imprensa Oficial, 2004.

Burrough, P.A. Principles of Geographic Information Systems for Land Resource Assessment. OUP, Oxford, 457 , 1986

REF.

BRASIL. Ministério do Meio Ambiente (MMA). Plano Nacional de Recursos Hídricos: documento base de referência: minuta: revisão. Brasília, DF: Secretaria Nacional de Recursos Hídricos; 2003

Buddemeier R.W and Schloss J.A , Groundwater storage and flow, a USGS publication funded by Kansas water plan fund .2000.

CEPIS (Centro Pan-Americano de Engenharia Sanitária e Ciências do Ambiente). Capítulo I: a água para o século XXI no mundo e em nossa região, 2000. Disponível em: <http://www.cepis.org.pe/eswww/dias/diainter/anos/2000/diapor.pdf>. Acesso em: 21 Fev. 2022.

Chandio I.A, Matori A.N.B, WanYusof K.B, Talpur M.A.H, Balogun A.L, Lawal D.U. GIS-based analytic hierarchy process as a multicriteria decision analysis instrument: a review. Arab J Geosci 6(8):3059–3066;2013

Chaterjee R.S, Bhattacharya A.K. Delineation of drainage pattern of coal basin related inference using satellite remote sensing techniques. Asia Pacific Rem Sen J1:107–114; 1995

Chavez S, Velasco G, Bowell J, Sides C, Gonzalez R, & Slotesz L. Groundwater resource evaluation. United States Geological Surveys (USGS)-Open Files Report-Of-96-739. 1997

Chowdhury A, Jha M.K, Chowdary V.M. Delineation of groundwater recharge zones and identification of artificial recharge sites in West Medinipur District, West Bengal using RS, GIS and MCDM techniques. Environ Earth Sci 59(6):1209–1222; 2010

Coelho, M. A.. Geografia do Brasil. São Paulo: Moderna, 400 p. 1996.

CPRM - Companhia de Pesquisa de Recursos Minerais, Serviços Geólogicos do Brasil Carta Geológia da Bahia, escala 1:100000, CPRM 2010

Dar I, Sankar K, Dar M. Remote sensing technology and geographic information system modeling: an integrated approach towards the mapping of groundwater potential zones in Hardrock terrain, Mamundiyar basin. J Hydrol 394(3–4):285–295; 2010

Das, N., Mukhopadhyay, S. Application of multi-criteria decision making technique for the assessment of groundwater potential zones: a study on Birbhum district, West Bengal, India. Environ Dev Sustain 22, 931–955; 2020.

Das, B., Pal, S.C. Assessment of groundwater recharge and its potential zone identification in groundwater-stressed Goghat-I block of Hugli District, West Bengal, India. Environ Dev Sustain 22, 5905–5923; 2020.

Das, S., Pardeshi, S.D. Comparative analysis of lineaments extracted from Cartosat, SRTM and ASTER DEM: a study based on four watersheds in Konkan region, India. Spat. Inf. Res. 26, 47–57; 2018.

REF.

Das, S., Gupta, A., Ghosh, S. Exploring groundwater potential zones using MIF technique in semi-arid region: a case study of Hingoli district, Maharashtra. Spat. Inf. Res. 25, 749–756 ; 2017.

Deepa, S., Venkateswaran, S., Ayyandurai, R. et al. Groundwater recharge potential zones mapping in upper Manimuktha Sub basin Vellar river Tamil Nadu India using GIS and remote sensing techniques. Model. Earth Syst. Environ. 2, 137; 2016.

Deepika B, Avinash K, Jayappa K.S. Integration of hydrological factors and demarcation of groundwater prospect zones: insights from remote sensing and GIS techniques. Environ Earth Sci 70(3):1319–1338; 2013

Deshmukh, K.K., Aher, S.P. Assessment of the Impact of Municipal Solid Waste on Groundwater Quality near the Sangamner City using GIS Approach. Water Resource Manage. 30 (7), 2425–2443;2016

Dissanayake D.M.D.O.K. Remote sensing and GIS approach for delineating and characterization of groundwater potential zones in hard rock terrain. Conference Proceedings of Map Asia 2006, Bangkok, Thailand, 24 Aug–1 Sept 2006.

Doke, A., Pardeshi, S.D., Pardeshi, S.S., Das, S. Identification of morphogenetic regions and respective geomorphic processes: a GIS approach. Arabian J. Geosci. 11, 1–13. 2018

Dunning D.J, Ross Q.E, Merkhofer M.W. Multiattribute utility analysis for addressing Section 316 (b) of the Clean Water Act. Environ Sci Policy 3:7–14; 2000

Eastman J.R. IDRISI Kilimanjaro: guide to GIS and image processing. Clark Labs, Clark University,Worcester, pp 328; 2003

Edet, A.E, Okereke, C.S. Assessment of hydrogeological conditions in basement aquifers of the Precambrian Oban massif, southeastern Nigeria. Journal of Applied Geophysics, 36(1), 195–204. 1997

Edet, A.E., Teme, S.C., Okereke, C.S; Esu, E.O. Lineament analysis for groundwater exploration in Precambrian Oban Massif and Obudu Plateau. SE Nigeria. Journal of Mining Geology, 30 (1), 87–95. 1994

El-Baz F, El-Ashry M. Groundwater for a thirsty earth. Geotimes 36(6):15–18; 1991

ESRI. Environmental Systems Research Institute, ArcGIS Professional GIS, ArcgisPro. Software Help . 2020.

FAO. World reference base for soil resources. World soil resources reports, 84, 21-22.1998

Fashae, O.A., Tijani, M.N., Talabi, A.O, Adedeji, O.I . Delineation of groundwater potential zones in the crystalline basement terrain of SW-Nigeria: an integrated GIS and remote sensing approach. Applied Water Science, 4(1), 19-38.2013

Fetter, C.W. Applied Hydrogeology, 4th ed. Prentice Hall, Englewood Cliffs, NJ,543–591, 1994

REF.

Flug M, Seitz H.L.H, Scott J.F.Multicriteria decision analysis applied to Glen Canyon Dam. J Water Resour Plan Manage ASCE 126(5):270–276; 2000

Freeze, R.A., Cherry, J.A.Groundwater. Englewood Cliffs, NJ, Printice-Hall Inc., 604p.1979

FUNDAJ (Fundação Joaquim Nabuco). Águas doces no Brasil. 2003

Haridas, V.R., Aravindan, S. Girish, G. Remote sensing and its applications for groundwater favourable area identification. Quarterly Journal of GARC 6,18-22. 1998

Haridas, V.R., Aravindan, S & Girish, G. Remote sensing and its applications for groundwater favourable area identification. Quarterly Journal of GARC 6,18-22.1998

Hill, J.M., Harlow, C.A. Zimmerman, P. Geographic information systems as applied to the manipulation of environmental data. The Environmentalist, vol. 3(1), pp. 33–38. 1983

Ganapuram S, Vijaya Kumar GT, Murali Krishna IV, Ercan K & CüneydDemirel M. Mapping of groundwater potential zones in the Musi basin using remote sensing data and GIS. Advances in Engineering Software, 40(7), 506- 518, 2008

Gimblett, R. Innovations in computer labs. Linking perception research, visual simulations and dynamic modeling within a GIS framework: The ball state experience computers. Environment and Urban Systems, vol. 13(2), pp. 109–123. 1989

Gitas I.Z, Ayanz J.S.M, Chuvieco B.D.E, Camia A. Advances in remote sensing and GIS applications in support of forest fire management. Int J Wildland Fire 23:603–605; 2014

Gonçalves R.D., Engelbrecht B.Z., Chang H.K, Análise hidrológica de séries históricas da bacia do Rio Grande (BA): contribuição do Sistema Aquífero Urucuia in Águas Subterrâneas 30(2):190-208; 2016.

Gopinath G, Saralathan P. Identification of groundwater prospective zones using IRS- 1D LISS and pump test methods. J Indian Soc Remote Sens 32:329–342; 2004

Hajkowicz S, Higgins A. A comparison of multiple criteria analysis techniques for water resource management. Eur J Oper Res 184:255–265; 2008

Haridas, V.R., Aravindan, S , Girish, G. Remote sensing and its applications for groundwater favourable area identification. Quarterly Journal of GARC 6,18-22.1998

Heinen, C.; Brinckmann, W. E.; Brinckmann, C.A. Aquífero Guarani.. Santa Cruz do Sul: Núcleo de Pesquisa e Extensão em Gerenciamento de Recursos Hídricos da Universidade de Santa Cruz do Sul – UNISC, Boletim Informativo, v. 4, n. 2, fev. 2001

Hoffmann, J. e Sander, P., Remote sensing and GIS in hydrogeology. Hydrogeology Journal, vol. 15(1), pp. 1–3 , 2007

REF.

Holland, M. Hydrogeological characterisation of crystalline basement aquifers within the Limpopo Province, South Africa. PhD Thesis, University of Pretoria, Pretoria, pp.80-112. 2011

Horton, R. E. Infiltration and runoff during the snow-melting season, with forest- cover. Eos, Transactions American Geophysical Union, 26(1), 59-68. 1945

IBGE, Instituto Brasileiro de Geografia e Estatística, Censo demográfico Nacional, Rio de Janeiro, 2010.

IGM (Instituto Geológico e Mineiro). Água subterrânea: conhecer para preservar o futuro. Portugal: Instituto Geológico e Mineiro, 2001.

INMET- Instituto Nacional de Meteorologia – Estações Meteorológicas- in https://bdmep.inmet.gov.br/

Israil M, Al-hadithi M, Singhal DC. Application of a resistivity survey and geographical information system (GIS) analysis for hydrogeological zoning of a piedmont area, Himalayan foothill region, India. Hydrogeol J 14:753–759; 2006

James, O.B. e Hedenquist, J.W. Consortium breccia 73255: Petrology of aphanitic lithologies (abs). Lunar Planet. Sci. IX. Lunar Planetary Institute, Houston, pp. 585-587. 1978

Jain, S.K., Agarwal, P.K. and Singh, V.P. Hydrology and Water Resources of India. Springer, Dordrecht, 1258, 2007.

Jarvis, A.; Rubiano, J.; Nelsom, A.; Farrow, A.; Mulligan, M. Practical use of SRTM data in the tropics -comparisons with digital elevation models generated from cartographic data. International Center for Tropical Agriculture, Palmira, n.198, p.1-32, 2004.

Jha M.K, Chowdhury A, Chowdary VM, Peiffer S. Groundwater management and development by integrated remote sensing and geographic information systems: prospects and constraints. Water Resour Manag 21(2):427–467; 2007

Jha, M.K., Chowdary, V.M., Chowdhury, A. Groundwater assessment in salboni block, west Bengal (India) using remote sensing, geographical information system and multi-criteria decision analysis techniques. Hydrogeol. J. 18, 1713–1728, 2010

Joubert A, Stewart T.J, Eberhard R. Evaluation of water supply augmentation and water demand management options for the City of Cape Town. J Multi-Criteria Decis Anal 12(1):17–25; 2003

Junge B, Alabi T, Sonder K, Marcus S, Abaidoo R, Chikoye D, Stahr K. Use of remote sensing and GIS for improved natural resources management: case study from different agroecological zone of West Africa. Int J Remote Sens 31:5116–6141; 2010

Kääb, A. Combination of SRTM3 and repeat ASTER data for deriving alpine glacier flow velocities in the Bhutan Himalaya. Remote Sensing of Environment, New York, v.94, n.4, p. 463474, 2005.

REF.

Kaliraj S, Chandrasekar N, Magesh N.S. Identification of potential groundwater recharge zones in Vaigai upper basin, Tamil Na du, using GIS-based analytical hierarchical process (AHP) technique. Arab J Geosci 7:1385–1401; 2014

Kar, A. Lineament Control on Channel Behavior during the 1990 Flood in the South eastern Thar Desert. International Journal o f Remote Sensing, 15(1), 2521-2530.1994

Kocak, G.; Buyuksalih, G.; Oruc, M. Accuracy assessment of interferometric digital elevation models derived from the Shuttle Radar Topography Mission X-and C-band data in a test area with rolling topography and moderate forest cover. Optical Engineering, Bellingham, v.44, n.3, 2005.

Konikow, L.F., Kendy, E. Groundwater depletion: A global problem. Hydrogeol J 13, 317–320 , 2005.

Koopmans, B.N. A comparative study of lineament analysis from different remote sensing imagery over areas in the Benue Valley and Jos Plateau Nigeria. International Journal of Remote Sensing, 7(1), 1763-1771.1986

Kousalya, P., Reddy, G. M., Supraja, S., & Prasad, V. Analytical Hierarchy Processapproach – An application of engineering education. Mathematica Aeterna, 2 ,no. 10,861 – 878, 2012.

Krishnamurthy J, Srinivas G. Role of geological and geomorphological factors in ground water exploration: a study using IRS LISS data. Int J Remote Sens 16:2595–2618; 1995

Kuria D, Gachari M, Macharia M, Mungai E. Mapping groundwater potential in Kitui District, Kenyausing geospatial technologies. Int J Water Res Environ Eng 4(1):15–22; 2012

Leal, Antônio de Souza. As águas subterrâneas no Brasil: ocorrências, disponibilidades e usos. In: FREITAS, Marcos Aurélio Vasconcelos de (Org.). O Estado das Águas no Brasil. Brasília: Agência Nacional de Energia Elétrica; Superintendência de Estudos e Informações Hidrológicas; Ministério do Meio Ambiente; Secretaria de Recursos Hídricos; Ministério de Minas e Energia,334p, 1999

Leduc, C., Favreau, G. and Schroeter, P. Long-term rise in a Sahelian water table: the Continental Terminal in southwest Niger. Journal of Hydrology, vol. 243, pp. 43–54.2001

Lehr, J H, Keeley, J.W., Lehr, K.K &. Kingery, T.B. Water encyclopedia. 2005

Lillesand, T., Special Issue Symposum on Geographic Information Systems. Satellite remote sensing: Its evolution and synergism with GIS technology. Government Information Quarterly, vol. 7(3), pp. 307–327.1990

Lillesand T;M, Kiefer R.W. Remote sensing and image interpretation. Wiley, New York, 2000

Lyle, J. e Stutz, F.P., Computerised land use suitability mapping. The Cartographic Journal, vol. 20(1), pp.39-49. 1983

REF.

Luedeling, E.; Siebert, S.; Buerkert, A. Filling the voids in the SRTM elevation model A TIN-based delta surface approach. ISPRS Journal of Photogrammetry & Remote Sensing, New York, v.62, n.4, p.283-294, 2007.

Machiwal D, Jha M.K, Mal B.C. Assessment of groundwater potential in a Semi-Arid region of india using remote sensing, GIS and MCDM techniques. Water Resour Manage 25:1359–1386; 2011

Madan, K.J., Chowdary, V.M. & Chowdhury, A.Groundwater assessment in Salboni Block, West Bengal (India) using remote sensing, geographical information system and multi-criteria decision analysis techniques Hydrogeology Journal, 18(7), 1713–1728, 2010

Madrucci V, Taioli F, Cesar De Araujo C. Groundwater favorability map using GIS multicriteria data analysis on crystalline terrain, Sao Paulo State, Brazil. J Hydrol 357:153–173; 2008 Maity, D.K., Mandal, S. Identification of groundwater potential zones of the Kumari river basin, India: an RS & GIS based semi-quantitative approach. Environ. Dev. Sustain. 21, 1013–1034; 2019

Magesh, N.S., Chandrasekar, N. and Soundranayagam, J.P. Delineation of groundwater potential zones in Theni district, Tamil Nadu, using remote sensing, GIS and MIF techniques. Geoscience Frontiers, vol. 3(2), pp. 189-196. 2012

Malczewski, J. GIS and multicriteria decision analysis. New York, NY: Wiley.1999

Mallick, J., Singh, C. K., Al-Wadi, H., Ahmed, M., Rahman, A., Shashtri, S. and Mukherjee, S. Geospatial and geostatistical approach for groundwater potential zone delineation, Hydrol. Process., 29, p395– 418; 2015

Manap MA, Sulaiman WNA, Ramli MF, Pradhan B, Surip N. A knowledge-driven GIS modeling technique for groundwater potential mapping at the Upper Langat Basin, Malaysia. Arab J Geosci 6:1621–1637, 2011

Marghany, M., Hashim, M. and Mansor S.Geologic mapping of United Arab Emirates using multispectral remotely sensed data. American Journal of Engineering and Applied Sciences, vol. 2(2), pp. 476-480.2009

Margat J. , Van de Gun J. Groundwater Around the World , CRC Press Taylor & Francis Group, Broken Sound Parkway NW, 2013

Maheswaran, M., Ali, S., Siegel, H. J., Hensgen, D., and Freund, R. F. Dynamic mapping of a class of independent tasks onto heterogeneous computing systems. Journal of parallel and distributed computing, 59(2), 107-131.1999

Meijerink, A.M.J. Remote sensing applications to groundwater IHP-VI, Series on Groundwater No. 16, UNESCO, Paris.,2007

Melloul, A.J., Collin, M.L., A hierarchy of groundwater management, land-use, and social needs integrated for sustainable resource development. Environ. Dev. Sustain. 3, 45–59. 2001

REF.

Mendes, C.A.B.; Cirilo, J.A. **Geoprocessamento em recursos hídricos: princípios, integração e aplicação.** Porto Alegre: ABRH, **2001**. 536 p.

Mogaji, K.A., Lim, H.S., Abdullah, K. **Regional prediction of groundwater potential mapping in a multifaceted geology terrain using GIS-based Dempster–Shafer** model. Arab J Geosci 8, 3235–3258; **2015**

Mogaji K. A., Aboyeji, O. S. and Omosuyi, G.O. **Mapping of lineaments for groundwater targeting in basement complex area of Ondo state using remotely sensed data.** Department of Applied Geophysics, Federal University of Technology, Akure, Nigeria Regional Centre for Training in Aerospace Surveys (RECTAS). **2012**

Moreira, M. C.; Silva, D. D. **Atlas hidrológico da bacia hidrográfica do rio Grande.** BarreirasBA, 75 p. **2010**

Morelli, M. and Piana, F. **Comparison between remote sensed lineaments and geological structures in intensively cultivated hills (Monferrato and Langhe domains, NW Italy).** International Journal of Remote Sensing, vol. 27(20), pp. 4471–4493. **2006**

Murthy K.S.R, Mamo AG. **Multi-criteria decision evaluation in groundwater zones identification in Moyale-Teltele subbasin, South Ethiopia.** Int J Remote Sens 30:2729–2740; **2009**

Mwega, B. W., Mati, B. M., Mulwa, J. K., and Kituu, G. M. **Application of electrical resistivity method to investigate groundwater potential in Lake Chala watershed.** International Academic Research for Multidisciplinary, 3(7). **2015**

Nagaraju, A., Sreedhar, Y., Thejaswi, A., and Dash, P. **Integrated Approach Using Remote Sensing and GIS for Assessment of Groundwater Quality and Hydrogeomorphology in Certain Parts of Tummalapalle Area, Cuddapah District, Andhra Pradesh, South India.** Advances in Remote Sensing, 5 (02), 83. **2016**

Naghibi Sa, Pourghasemi Hr, Pourtaghi Zs, Rezaei A. **Groundwater qanat potential mapping using frequency ratio and Shannon's entropy models in the Moghan watershed. Iran** Earth Sci Inform 8:1–16.**2015**

Naghibi Sa, Pourghasemi Hr, Dixon B (2016) **GIS-based groundwater potential mapping using boosted regression tree, classification and regression tree, and random forest machine learning models in Iran.** Environ Monit Assess 188:44.**2016**

Nandi, A. Shakoor, A **GIS-based landslide susceptibility evaluation using bivariate and multivariate statistical analyses**, Engineering Geology, Volume 110, Issues 1–2, Pags 11-20, **2010**

Nampak H, Pradhan B, Manap M.A. **Application of GIS based data driven evidential belief function model to predict groundwater potential zonation.** J Hydrol 513:283–300; **2014**

Nas B, Berktay A. **Groundwater quality mapping in urban groundwater using GIS**. Environ Monit Assess. 160 (1-4):215-27. Jan; **2010**

REF.

Olayinka, A.I, Olayiwola, M.A. Integrated use of geoelectrical imaging and hydrochemical methods in delineating limits of polluted surface and groundwater at a landfill site in Ibadan area, southwestern Nigeria. Journal of Mining and Geology 37 (1), 53-68, 2001

O'Leary, D.W., Friedman, J.D. and Pohn, H.A. Lineament, linear, lineation: Some proposed new standards for old terms. Geological Society America Bulletin, vol. 87, pp. 1463- 1469. 1976

Olorunfemi, M.O., Dan-Hassan, M.A., Ojo, J.S. (1995).On the scope and limitations of the electromagnetic methods in groundwater prospecting in a Precambrian basement terrain a Nigerian case study. Journal of African Earth Sciences, 20 (2), 151–160,1995

Pande, C.B., Moharir, K.N., Singh, S.K., Varade, A.M. An integrated approach to delineate the groundwater potential zones in Devdari watershed area of Akola district, Maharashtra, CentralIndia. Environ. Dev. Sustainability 22, 4867–4887; 2019

Parameswari, K., Padmini, T.K. Assessment of groundwater potential in Tirukalukundram block Of Southern Chennai Metropolitan Area. Environ. Dev. Sustain. 20 (9); 2018

Paranhos Filho, A. C., Lastoria, G., Torres, T. G. Sensoriamento Remoto Ambiental Aplicado: Introdução às Geotecnologias. Campo Grande-MS: Editora UFMS, 1 ed. 198 p. 2008

Peixoto, J. P. Oort, A. H. Lê cycle de l'eau et le. La Recherche. Spécial: L'eau, v.21, p. 570-79, 1990.

Philip, G. Landsat Thematic Mapper Data Analysis for Quaternary Tectonics in Parts of the Doon Valley, NW Himalaya, India. International Journal of Remote Sensing, 17(1), 143-153.1996

Pinto D, Shrestha S, Babel MS, Ninsawat S. Delineation of groundwater potential zones in the Comoro watershed, Timor Leste using GIS, remote sensing and analytic hierarchy process (AHP) technique. Appl Water Sci. 2005

Pietersen K. Multiple criteria decision analysis (MCDA): a tool to support sustainable management of groundwater resources in South Africa. Water SA 32(2):119–128; 2006

PNUD - Programa das Nações Unidas para o Desenvolvimento. Agenda 2030 para o desenvolvimento sustentável: subsídios iniciais do Sistema das Nações Unidas no Brasil sobre a identificação de indicadores nacionais referentes aos objetivos de desenvolvimento sustentável/Programa das Nações Unidas para o Desenvolvimento. Brasília: PNUD, 2015. 291 p. : Il. Color.

Pothiraj P, Rajagopalan B. A GIS and remote sensing based evaluation of groundwater potential zones in a hard-rock terrain of Vaigai sub-basin, India. Arab J Geosci. 2012

REF.

Pourghasemi H.R, Moradi H.R, Fatemi Aghda S.M, Gokceoglu C., Pradhan B. GIS-based landslide susceptibility mapping with probabilistic likelihood ratio and spatial multi-criteria evaluation models (North of Tehran, Iran). Arab J Geosci 7(5):1857–1878; 2012

Pradhan B. Groundwater potential zonation for basaltic watersheds using satellite remote sensing data and GIS techniques. Cent Eur J Geosci 1(1):120-129; 2009

Prasad R.K, Mondal N.C, Banerjee P, Nanda Kumar M.V, Singh V.S. Deciphering potential groundwater zone in hard rock through the application of GIS. Environ Geol 55:467–475; 2008

PROASNE. Ministério de Minas e Energia. CPRM - Serviço Geológico do Brasil. Diretoria de Hidrologia e Gestão Territorial. A água subterrânea no mundo, 2003

Rahmati, O., Nazari, S. A., Mahdavi, M., Pourghasemi, H. R., Zeinivand, H. Groundwater potential mapping at Kurdistan region of Iran using analytic hierarchy process and GIS. Arabian Journal of Geosciences, 8 (9). 7059-7071, 2015

Rahmati O., Pourghasemi H. R., Melesse A. M., Application of GIS-based data driven random forest and maximum entropy models for groundwater potential mapping: A case study at Mehran Region, Iran, Catena, Volume 137, Pg 360-372; 2016

Rao Y.S, Jugran D.K. Delineation of groundwater potential zones and zones of groundwater quality suitable for domestic purposes using remote sensing and GIS. Hydrol Sci J 48(5):821–833, 2003

Raghunath H.M. Hydrology: Principles, Analysis, Design, Second edition. New Age International (P) Limited, Publishers, Manipal, Karnataka, India. Pp 477, 2006

Rashman. Identification of Groundwater recharge potential zones in Thiruverumbur block, Trichy district using GIS and remote sensing. 2016

Ravindran KV, Jeyaram A. Groundwater prospects of Shahbad Tehsil, basan district, eastern Rajasthan. A remote sensing approach. J of Indian Soc Remote Sens 25:239–246; 1997

Razandi, Y., Pourghasemi, H.R., Neisani, N.S. et al. Application of analytical hierarchy process, frequency ratio, and certainty factor models for groundwater potential mapping using GIS. Earth Sci Inform 8, 867–883; 2015.

Rebouças, A. C. Águas subterrâneas nas grandes metrópoles: água subterrânea no novo modelo do saneamento básico, 1996

Rebouças,A. C.; Braga, B; Tundisi, José Galizia. Águas doces no Brasil: Capital ecológico, uso e conservação. 2. ed. rev. e ampl. São Paulo: Escrituras, 2002. 702p

Rekha V.B., Thomas A.P. Integrated remote sensing and GIS for groundwater potentially mapping in Koduvan Àr-Sub-Watershed of Meenachil river basin, Kottayam District, Kerala. School of Environmental Sciences, Mahatma Gandhi University, Kerala, 2007

REF.

Rennó, C.D.; Nobre, A.D.; Cuartas, L.A.; Soares, J.V.; Hodnett, M.G.; Tomasella, J.; Waterloo, M.J. Hand, a new terrain descriptor using SRTM-DEM: Mapping terra-firme rainforest environments in Amazonia. Remote Sensing of Environment, New York, v.112, n.9, p.3469-3481, 2008.

Robinson, G.M., Gray, D.A., Healey, R.G. and Furley, P.A., Developing a geographical information system (GIS) for agricultural development in Belize, Central America. Applied Geography, vol. 9(2), pp. 81–94. 1989.

Rodriguez, E.; Morris, C.S.; Belz, J.E. A global assessment of the SRTM performance. Photogrammetric Engineering and Remote Sensing, Bethesda, v.72, n.3. p. 249-260, 2006.

Roscoe, M C. Handbook of Ground Water Development. Wiley, New York, pp 34–51, 1990

Saaty T.L. The analytic hierarchy process: planning, priority setting, resource allocation. McGraw-Hill, New York; 1980

Saaty T.L. Axiomatic foundation of the analytic hierarchy process. Manage Sci 32:841–855; 1986

Saaty T.L. The hierarchon: a dictionary of hierarchies. RWS Publications, Pittsburgh, p 496; 1992

Sajikumar, N., Gigo, P. Integrated Remote Sensing and GIS Approach for Groundwater Exploration using Analytic Hierarchy Process (AHP) Technique. International Journal of Innovative Research in Science, Engineering and Technology, 2, Special Issue 1, 2013.

Sampat, Payal. Expondo a poluição freática. In: WORLDWATCH INSTITUTE. Estado do Mundo: 2001. Relatório Anual do WWI-Worldwatch Institute/UMA-Universidade Livre da Mata Atlântica, 2001

Salwa. F. An overview of integrated remote sensing and GIS for groundwater mapping in Egypt. Ain Shams Engineering Journal, 6(1), 1-15.2015

Sander, P. Lineaments in groundwater exploration: a review of applications and limitations. Hydrogeology Journal, vol. 15(1), pp. 71–74. 2007

Sener E, Davraz A & Ozcelik M. An integration of GIS and remote sensing in groundwater investigations: A case study in Burdur, Turkey. Hydrogeology Journal, 13(5-6), 826-834. 2005

Shaban, A., Khawlie, M & Abdallah, C. Use of remote sensing and GIS to determine recharge potential zone: the case of Occidental Lebanon. Hydrogeology Journal 14(1), 433-443. 2006

Shahid S, Nath SK, Roy J. Groundwater potential modeling in a softrock area using a GIS. Int J Remote Sens 21(9):1919–1924; 2000

Saraf A.K. A report on landscape modelling in gis for bankura district, project sponsored by DST, NRDMS division Govt. of India; 1999

REF.

Saravanan, S., Saranya, T., Jennifer, J.J. et al. Delineation of groundwater potential zone using analytical hierarchy process and GIS for Gundihalla watershed, Karnataka, India. Arab J Geosci 13, 695 , 2020.

Sener E, Davraz A, Ozcelik M. An integration of GIS and remote sensing in groundwater investigations: a case study in Burdur, Turkey. Hydrogeol J 13(5–6):826–834; 2005

Shiklomanov, I. A. World Water Resources: A New appraisal and assesment for the 21° Century . Paris , UNESCO, 76p. , 1998

Silva, F.F. da; Neto, A.V.L; Cardoso. E.C. Schuster, H.D.M. Aplicação da modelagem matemática no uso conjunto água superficial e subterrânea para a gestão de recursos hídricos no oeste do estado da Bahia. In: Simpósio de Recursos Hídricos da Amazônia, 2, 2005, Palmas. Resumos...palmas: Associação Brasileira de Recursos Hídricos, 2005

Silva, A. L. M. S. Águas subterrâneas: critérios em seu uso. Fórum Internacional das Águas, 2003.

SMA (Secretaria de Estado do Meio Ambiente do Estado de São Paulo). Projeto GEF: Gerenciamento Integrado e Sustentável do Aquífero Guarani, 2000.

Smith, B.; Sandwell, D. Accuracy and resolution of shuttle radar topography mission data. Geophysical Research Letters, Washington, v.30, n.9, p.1-4, 2003.

SNIRH – Sistema Nacional de Informação de Recursos Hídricos, Portugal, Tipos de aquíferos, e furos segundo a pressão In http://snirh.apambiente.pt , 2017

Solomon S, Quiel F. Groundwater study using remote sensing and geographic information systems (GIS) in the central highlands of Eritrea. Hydrogeol J 14:729–741; 2006

Sreela, R., Girish, G., Reji, S., Rajesh, R. and Kurian, S. Demarcation of groundwater prospective zones in humid tropical river basin: A geospatial approach. Iranian Journal of Earth Sciences, vol. 5(1), pp. 1-12. 2013

Srinivas Rao Y, Reddy T.V.K., Nayudu P.T. Groundwater targeting in hard rock terrain using fracture battern modelling, Niva river basin, Andhra Pradesh, India. Hydrogeol J 8:494–502; 2000

Srivasthava P.K, Bhattacharya A.K Delineation of groundwater potential zones in a hard rock terrain of Baragarh district, Orrissa using IRS data. J Indian Soc Remote Sens 28(2&3):129–140; 2000

SRSH – Secretaria de Recursos Hídricos, Saneamento e Habitação. Documento Síntese. In: Plano Diretor de Recursos Hídricos: Bacia do rio Grande. Salvador: Higesa, 1993. 166p

Stute, M., Zheng, Y., Schlosser, P., Horneman, A., Dhar, R.K., Hoque, M.A., Seddique, A.A., Shamsudduha, M., Ahmed, K.M & van Geen, A. Hydrological control of As

REF.

concentrations in Bangladesh groundwater.Water Resources Research, 43(9), W09417. 2007

Sun, G.; Ranson, K.J.; Khairuk, V.I.; Kovacs, K. Validation of surface height from shuttle radar topography mission using shuttle laser altimeter. Remote Sensing of Environment, New York, v.88, n.4, p.401-411, 2003.

Thapa, R., Gupta, S., Guin, S., & Kaur, H. Assessment of groundwater potential zones using multi-influencing factor (MIF) and GIS: A case study from Birbhum district, West Bengal. Applied Water Science, Vol.7, Issue 7, pp 4117–4131. 2017

Teferi E., Bewket W., Uhlenbrook S., Wenninger J., Understanding recent land use and land cover dynamics in the source region of the Upper Blue Nile, Ethiopia: Spatially explicit statistical modeling of systematic transitions, Agriculture, Ecosystems & Environment, Volume 165, P. 98-117; 2013

Tesfaye, T. Ground water potential evaluation based on integrated GIS and remote sensing techniques, in bilate river catchment: south rift valley of Ethiopia (AAU). 2012

Thannoun R G. Automatic Extraction and Geospatial Analysis of Lineaments and their Tectonic Significance in some areas of Northern Iraq using Remote Sensing Techniques and GIS. International Journal of Enhanced Research in Science Technology & Engineering. 2(1), 1–11. 2013

Thomas, R. & Duraisamy, V. Hydrogeological delineation of groundwater vulnerability to droughts in semi-arid areas of western Ahmednagar district. The Egyptian Journal of Remote Sensing and Space Science. 21(2) 121–137. 2017

Toleti B.V. M, Chaudhary B.S, Kumar K.E, Saroha G.P, Yadav M, Singh A, Sharma M. P, Pandey A. C, Singh P. K. Integrated groundwater resources mapping in Gurgaon district, (Haryana) India using remote sensing and GIS techniques. The 21st Asian Conf. on Remote Sensing, Taipei, Taiwan, Dezembro 4–8, 2000

Travaglia, C e Dainelli, N. Groundwater search by remote sensing: A methodological approach (No. 551.49 T779g). Rome, IT: FAO. 2003

Trimmer, W.L. Measuring well water level, Extension Service: Oregon State University Sea Grant Extension Ec 136. 2000

Turcotte, R.; Fortin, J.P.; Rousseau, A.N.; Massicotte, S.; Villeneuve, J.P. Determination of the drainage structure of a watershed using a digital elevation model and a digital river and lake network. Journal of Hydrology, Amsterdam, v.240, n.3, p.225-242, 2001.

Tundisi, J. G. Água no século XXI: enfrentando a escassez. 2 ed. São Carlos: RiMA, 2005.

UNESCO -United Nations Educational, Scientific and Cultural Organization, Grundwater Resources of the world and their use , 7 place de Fontenoy, 75352 Paris 07 SP, 2004

REF.

UNESCO (United Nations Educational, Scientific and Cultural Organization). Internationally shared (transboundary) aquifer resources management (ISARM): their significance and sustainable management, 2001.

Vasanthavigar, M., Srinivasamoorthy, K., Vijayaragavan, K., Gopinath, S. and Sarma, S. Groundwater Potential Zoning in Thirumanimuttar Sub-Basin Tamilnadu, India—A GIS and Remote Sensing Approach. Geo-spatial Information Science, vol. 14(1), pp. 17-26. 2011

Valeriano, M.M. Dados topográficos. In: Florenzano, T.G. (Org.). Geomorfologia, conceitos e tecnologias atuais São Paulo: Oficina de Textos, 2008. p.72-104.

Wrege, Mário. Termos hidrogeológicos básicos. Caderno Técnico ABAS, São Paulo,. Associação Brasileira de Águas Subterrâneas. 32p, n.4 ago. 1997

WSS – Water Science School in https://www.usgs.gov/special-topics/water-science-school acessado em 15 de Março de 2022

Yeh, H. F., Lin, H. I., Lee, S. T., Chang, M. H., Hsu, K. C., & Lee, C. H. GIS and SBF for estimating groundwater recharge of a mountainous basin in the Wu river watershed, Taiwan. Journal of Earth System Science, 123 (3), 503–516. 2014

Yeh, H.F., Cheng, Y.S., Lin, H.I & Lee, C.H. Mapping groundwater recharge potential zone using a GIS approach in Hualian River, Taiwan. Sustainable Environment Research, 26(1) 33-43. 2016