

## Appendix B

### Detail Result of GWR by GWR.4 software

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\* Semiparametric Geographically Weighted Regression \*

\* Release 1.0.74 (GWR 4.0.74) \*

\* 15 Aug 2013 \*

\* (Originally coded by T. Nakaya: 1 Nov 2009) \*

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Program began at 7/31/2013 7:51:11 PM

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Session: landslide susceptibility

Session control file: C:\Users\javad\Desktop\landslide.ctl

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Data file name: C:\Users\javad\Desktop\GeographicallyWeighted Regression.csv

Number of areas/points: 120

Model settings-----

Model type: Gaussian

Geographic kernel: adaptive bi-square

Method for optimal bandwidth search: Golden section search

Criterion for optimal bandwidth: AIC

Number of varying coefficients: 10

Number of fixed coefficients: 0

Modelling options-----

Standardisation of independent variables: On

Testing geographical variability of local coefficients: On

Local to Global Variable selection: On

Global to Local Variable selection: On

Prediction at non-regression points: OFF

Variable settings-----

Area key: field13: Key

Easting (x-coord): field12 : Longitude

Northing (y-coord): field11: Latitude

Cartesian coordinates: Euclidean distance

Dependent variable: field1: Landslide

Offset variable is not specified

Intercept: varying (Local) intercept

Independent variable with varying (Local) coefficient: field2: Soil

Independent variable with varying (Local) coefficient: field3: Slope

Independent variable with varying (Local) coefficient: field4: Landuse

Independent variable with varying (Local) coefficient: field5: Erosion

Independent variable with varying (Local) coefficient: field6: Lithology

Independent variable with varying (Local) coefficient: field7: Fault

Independent variable with varying (Local) coefficient: field8: River

Independent variable with varying (Local) coefficient: field9: Road

Independent variable with varying (Local) coefficient: field10: Aspect

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Global regression result

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< Diagnostic information >

Residual sum of squares:	2.302343
Number of parameters:	10
(Note: this num does not include an error variance term for a Gaussian model)	
ML based global sigma estimate:	0.138514
Unbiased global sigma estimate:	0.144673
Log-likelihood:	-133.882489
Classic AIC:	-111.882489
AICc:	-109.438044
BIC/MDL:	-81.220079
CV:	0.026698
R square:	0.907132
Adjusted R square:	0.898612

Variable	Estimate	Standard Error	t(Est/SE)
Intercept	0.705635	0.013210	53.417177
Soil	-0.009552	0.015420	-0.619418
Slope	0.026109	0.024872	1.049724
Landuse	0.028973	0.021450	1.350710
Erosion	0.056481	0.017480	3.231198
Lithology	0.054577	0.018635	2.928685
Fault	-0.098368	0.025612	-3.840755
River	-0.201712	0.025476	-7.917863
Road	-0.033692	0.017484	-1.926977
Aspect	0.029900	0.017059	1.752748

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### GWR (Geographically weighted regression) bandwidth selection

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Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL	Bandwidth:	60.000	Criterion:	-191.471	
p1	Bandwidth:	61.277	Criterion:	-188.531	
p2	Bandwidth:	62.067	Criterion:	-187.309	
pU	Bandwidth:	63.344	Criterion:	-186.902	
iter 1	(p1) Bandwidth:	61.277	Criterion:	-188.531	Diff: 0.789
iter 2	(p1) Bandwidth:	60.789	Criterion:	-191.471	Diff: 0.488
Best bandwidth size		60.000			

Minimum AIC            -191.471

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GWR (Geographically weighted regression) result

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Bandwidth and geographic ranges

Bandwidth size:            60.789337

Coordinate	Min	Max	Range
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X-coord	47.011300	47.312100	0.300800
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Y-coord	34.060200	34.950700	0.890500
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Diagnostic information

Residual sum of squares:                            0.665912

Effective number of parameters (model: trace(S)):            44.637402



Effective number of parameters (variance: trace(S'S)):	35.014836
Degree of freedom (model: n - trace(S)):	75.362598
Degree of freedom (residual: n - 2trace(S) + trace(S'S)):	65.740032
ML based sigma estimate:	0.074493
Unbiased sigma estimate:	0.100645
Log-likelihood:	-282.745433
Classic AIC:	-191.470630
AICc:	-133.446243
BIC/MDL:	-64.256749
CV:	0.027608
R square:	0.973140
Adjusted R square:	0.950627

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<< Geographically varying (Local) coefficients >>

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Estimates of varying coefficients have been saved in the following file.

Listwise output file: C:\Users\javad\Desktop\landslide\_listwise.csv

Summary statistics for varying (Local) coefficients

Variable	Mean	STD
Intercept	0.721094	0.019534
Soil	0.001738	0.008462
Slope	0.038973	0.069604
Landuse	0.013876	0.048794
Erosion	0.037689	0.040005
Lithology	0.034859	0.032327
Fault	-0.213290	0.177375
River	-0.101253	0.088733

Road	-0.018265	0.021044
Aspect	0.023472	0.044021

Variable	Min	Max	Range
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Intercept	0.671484	0.777487	0.106003
Soil	-0.030535	0.029942	0.060477
Slope	-0.019832	0.205060	0.224892
Landuse	-0.098382	0.148029	0.246412
Erosion	-0.005172	0.131310	0.136482
Lithology	0.000000	0.098232	0.098232
Fault	-0.441540	0.046100	0.487641
River	-0.283252	0.000000	0.283252
Road	-0.062597	0.021650	0.084247
Aspect	-0.020251	0.148391	0.168642

Variable	Lwr Quartile	Median	Upr Quartile
Intercept	0.721110	0.731092	0.733374
Soil	0.000000	0.000000	0.003973
Slope	-0.005268	0.000000	0.090388
Landuse	0.000000	0.000000	0.047415
Erosion	0.000000	0.023783	0.069516
Lithology	0.000000	0.037346	0.061693
Fault	-0.441540	-0.161281	-0.054224
River	-0.166856	-0.111022	0.000000
Road	-0.028741	-0.015474	0.000000
Aspect	0.000000	0.000000	0.036239

Variable	Interquartile R	Robust STD
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Intercept	0.012264	0.009091
Soil	0.003973	0.002945
Slope	0.095656	0.070909
Landuse	0.047415	0.035148
Erosion	0.069516	0.051531
Lithology	0.061693	0.045732
Fault	0.387316	0.287114
River	0.166856	0.123689
Road	0.028741	0.021305
Aspect	0.036239	0.026864

(Note: Robust STD is given by (interquartile range / 1.349) )

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GWR ANOVA Table

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Source	SS	DF	MS	F
Global Residuals	2.302	10.000		
GWR Improvement	1.636	44.260	0.037	
GWR Residuals	0.666	65.740	0.010	3.650055

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Geographical variability tests of local coefficients

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Variable	F	DOF for F	test	DIFF of Criterion
Intercept	0.193867	2.167	75.363	3.667447
Soil	0.120831	2.982	75.363	5.390746

Slope	4.428569	2.555	75.363	-11.674329
Landuse	4.946427	2.539	75.363	-13.416735
Erosion	3.550328	2.717	75.363	-9.018617
Lithology	1.211952	2.988	75.363	0.343963
Fault	17.405925	2.509	75.363	-49.835866
River	8.507981	2.281	75.363	-22.932866
Road	24.152475	2.860	75.363	-72.343568
Aspect	6.632047	2.482	75.363	-18.745189

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Note: positive value of diff-Criterion (AICc, AIC, BIC/MDL or CV) suggests no spatial variability

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There is no independent variables in the box of fixed (Global) coef.

(Global to Local) Variable selection is not conducted.

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(L -> G) Variable selection from varying coefficients to fixed coefficients

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Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL      Bandwidth:    60.000 Criterion: -136.376

p1      Bandwidth:    61.277 Criterion: -135.553

p2      Bandwidth:    62.067 Criterion: -135.860

pU      Bandwidth:    63.344 Criterion: -135.539

iter 1 (p2) Bandwidth: 62.067 Criterion: -135.860 Diff: 0.789

The lower limit in your search has been selected as the optimal bandwidth size.

A new session is recommended to try with a smaller lowest limit of the bandwidth search.

Best bandwidth size 60.000



Minimum AIC -136.376

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL	Bandwidth:	60.000	Criterion:	-115.159	
p1	Bandwidth:	82.918	Criterion:	-143.795	
p2	Bandwidth:	97.082	Criterion:	-125.557	
pU	Bandwidth:	120.000	Criterion:	-109.344	
iter 1	(p1) Bandwidth:	82.918	Criterion:	-143.795	Diff: 14.164
iter 2	(p2) Bandwidth:	82.918	Criterion:	-143.795	Diff: 8.754
iter 3	(p1) Bandwidth:	82.918	Criterion:	-143.795	Diff: 5.410
iter 4	(p2) Bandwidth:	82.918	Criterion:	-143.795	Diff: 3.344
iter 5	(p1) Bandwidth:	82.918	Criterion:	-143.795	Diff: 2.067
iter 6	(p1) Bandwidth:	81.641	Criterion:	-145.785	Diff: 1.277

iter 7 (p2) Bandwidth: 81.641 Criterion: -145.785 Diff: 0.789

iter 8 (p1) Bandwidth: 81.641 Criterion: -145.785 Diff: 0.488

Best bandwidth size 81.000

Minimum AIC -145.785

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL Bandwidth: 75.726 Criterion: NaN

p1 Bandwidth: 92.637 Criterion: NaN

p2 Bandwidth: 103.089 Criterion: NaN

pU Bandwidth: 120.000 Criterion: -38.341

Error in the initial weight calculation loop

Index was outside the bounds of the array. Best bandwidth size 0.000

Minimum AIC      NaN

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL      Bandwidth: 75.726 Criterion: NaN

p1      Bandwidth: 92.637 Criterion: NaN

p2      Bandwidth: 103.089 Criterion: NaN

pU      Bandwidth: 120.000 Criterion: NaN

Error in the initial weight calculation loop

Index was outside the bounds of the array.Best bandwidth size 0.000

Minimum AIC      NaN

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL      Bandwidth: 75.726 Criterion: NaN

p1      Bandwidth: 92.637 Criterion: NaN

p2      Bandwidth: 103.089 Criterion: NaN

pU      Bandwidth: 120.000 Criterion: NaN

Error in the initial weight calculation loop

Index was outside the bounds of the array.Best bandwidth size 0.000

Minimum AIC      NaN

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL      Bandwidth: 75.726 Criterion: NaN

p1      Bandwidth: 92.637 Criterion: NaN  
p2      Bandwidth: 103.089 Criterion: NaN  
pU      Bandwidth: 120.000 Criterion: NaN

Error in the initial weight calculation loop

Index was outside the bounds of the array.Best bandwidth size 0.000

Minimum AIC      NaN

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL      Bandwidth: 75.726 Criterion: NaN  
p1      Bandwidth: 92.637 Criterion: -114.073  
p2      Bandwidth: 103.089 Criterion: -111.052  
pU      Bandwidth: 120.000 Criterion: NaN

iter 1 (p1) Bandwidth: 92.637 Criterion: -114.073 Diff: 10.452  
iter 2 (p1) Bandwidth: 86.178 Criterion: -119.892 Diff: 6.459  
iter 3 (p1) Bandwidth: 82.186 Criterion: -123.529 Diff: 3.992  
iter 4 (p1) Bandwidth: 79.718 Criterion: -125.566 Diff: 2.467  
iter 5 (p1) Bandwidth: 78.193 Criterion: -125.622 Diff: 1.525  
iter 6 (p1) Bandwidth: 77.251 Criterion: -126.643 Diff: 0.942  
iter 7 (p2) Bandwidth: 77.251 Criterion: -126.643 Diff: 0.582

Best bandwidth size 77.000

Minimum AIC -126.643

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL Bandwidth: 60.000 Criterion: -156.100

p1 Bandwidth: 61.277 Criterion: -154.382

p2 Bandwidth: 62.067 Criterion: -154.855

pU Bandwidth: 63.344 Criterion: -155.081

iter1 (p2) Bandwidth: 62.067 Criterion: -154.855 Diff: 0.789

The lower limit in your search has been selected as the optimal bandwidth size.

A new session is recommended to try with a smaller lowest limit of the bandwidth search.

Best bandwidth size 60.000

Minimum AIC -156.100

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL Bandwidth: 60.000 Criterion: -129.207

p1 Bandwidth: 61.277 Criterion: -127.202

p2 Bandwidth: 62.067 Criterion: -127.422

pU Bandwidth: 63.344 Criterion: -125.877

iter1 (p2) Bandwidth: 62.067 Criterion: -127.422 Diff: 0.789

The lower limit in your search has been selected as the optimal bandwidth size.

A new session is recommended to try with a smaller lowest limit of the bandwidth search.

Best bandwidth size 60.000

Minimum AIC -129.207

Bandwidth search <golden section search>

Limits: 60, 120

Golden section search begins...

Initial values

pL Bandwidth: 60.000 Criterion: -133.641

p1 Bandwidth: 82.918 Criterion: -135.168

p2 Bandwidth: 97.082 Criterion: -106.961

pU Bandwidth: 120.000 Criterion: -109.149

iter 1 (p1) Bandwidth: 82.918 Criterion: -135.168 Diff: 14.164

iter 2 (p2) Bandwidth: 82.918 Criterion: -135.168 Diff: 8.754



iter 3 (p1) Bandwidth: 82.918 Criterion: -135.168 Diff: 5.410  
iter 4 (p1) Bandwidth: 79.574 Criterion: -137.222 Diff: 3.344  
iter 5 (p2) Bandwidth: 79.574 Criterion: -137.222 Diff: 2.067  
iter 6 (p1) Bandwidth: 79.574 Criterion: -137.222 Diff: 1.277  
iter 7 (p2) Bandwidth: 79.574 Criterion: -137.222 Diff: 0.789  
iter 8 (p1) Bandwidth: 79.574 Criterion: -137.222 Diff: 0.488

Best bandwidth size 79.000

Minimum AIC -137.222

The summary of the L -> G variable selection

model	AIC
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GWR model before L -> G selection	-191.470630
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GWR model after L -> G selection	-191.470630
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Improvement	0.000000
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Program terminated at 7/31/2013 7:51:29 PM