

Supplementary Material

a. Selection of sampling units (villages) and descriptive statistics of study variables

The map below illustrates the villages (clusters) selected in the districts of the Northern Province of Rwanda based on population density. The number of households visited and interviewed varied according to village size: 3–4 households for small villages, and 5–9 households for medium-sized and large villages.

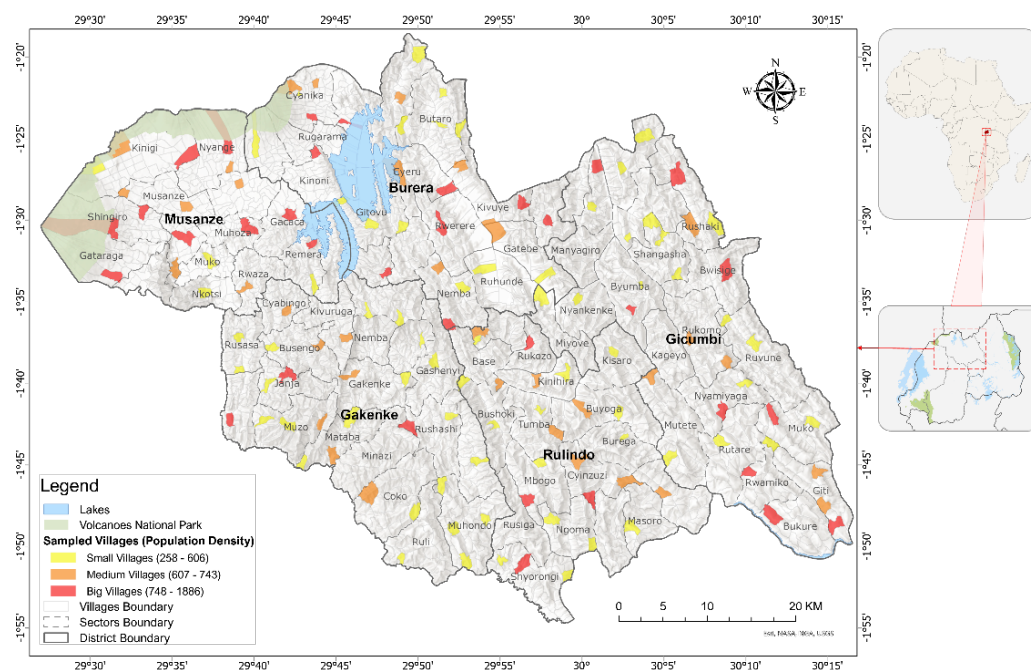


Figure S1 Map of Selected Villages (Clusters) in Northern Province

Table S1 : Description of outcome and explanatory variables used in the study

Variable name	Variable Description
Outcome Variable	
Height-for-age z-score (HAZ)	Continuous; standardized measure of linear growth relative to WHO growth reference, with stunting defined as HAZ < −2 standard deviations from median.
Child Health and Care Factors	
Age of child (months)	Continuous; age in months (range: 1–36)
Sex of child	Categorical: (1) Female, (2) Male
Birthweight	Continuous; recorded in grams
Underweight status	Categorical: (1) No, (2) Yes (weight-for-age below −2 SD of median)
Multiple birth	Categorical: (1) Single birth, (2) Twin or triplet
Current breastfeeding	Categorical: (1) No, (2) Yes
Days child left unattended (>1 hour)	Continuous; number of days left unattended in the past two weeks
Frequency of growth monitoring	Continuous; number of times child's growth measured in the last six months
Maternal Factors	
Maternal food support	Categorical: (1) Always, (2) Occasionally, (3) Never
Maternal personal or emotional support	Categorical: (1) Always, (2) Occasionally, (3) Never
Household Socioeconomic Factors	
Access to electricity	Categorical: (1) No, (2) Yes
Availability of handwashing facility	Categorical: (1) No, (2) Yes
Ownership of kitchen/home garden	Categorical: (1) No, (2) Yes
Farmland size	Categorical: (1) Landless, (2) <1 hectare, (3) ≥1 hectare
Household milk consumption	Categorical: (1) No milk consumption, (2) Regular consumption (fresh or fermented milk)

Table S2 Descriptive summary of selected explanatory variables.

		All N = 601	Not-stunted n = 438 (73%)	Stunted n = 163 (27%)
CONTINUOUS VARIABLES¹				
Age of the child (in months)		18 [10]	16 [10]	22 [8]
Birthweight (in grams)		3192 [501]	3247 [484]	3045 [517]
Number of days the child was left alone		1.04 [1.84]	1.00 [1.84]	1.12 [1.86]
Growth monitoring (number of times growth measurements taken in the last 6 months)		3.70 [2.00]	3.60 [2.01]	3.96 [1.96]
CATEGORICAL VARIABLES²				
Child sex	Female	311 (51.75%)	246 (56.2%)	65 (39.9%)
	Male	290 (48.25%)	192 (43.8%)	98 (60.1%)
Underweight status	No	560 (93.2%)	429 (97.9%)	131 (80.4%)
	Yes	41 (6.82%)	9 (2.05%)	32 (19.6%)
Child is a twin or triplet	No	562 (93.51%)	418 (95.4%)	144 (88.3%)
	Yes	39 (6.489%)	20 (4.57%)	19 (11.7%)
Currently breastfeeding	No	145 (24.13%)	87 (19.9%)	58 (35.6%)
	Yes	456 (75.87%)	351 (80.1%)	105 (64.4%)
The mother has food support	Always	164 (27.29%)	129 (29.5%)	35 (21.5%)
	Never	210 (34.94%)	145 (33.1%)	65 (39.9%)
	Occasionally	227 (37.77%)	164 (37.4%)	63 (38.7%)
The mother has support with personal problems	Always	245 (40.77%)	187 (42.7%)	58 (35.6%)
	Never	134 (22.30%)	89 (20.3%)	45 (27.6%)
	Occasionally	222 (36.94%)	162 (37.0%)	60 (36.8%)
Access to electricity	No	375 (62.40%)	253 (57.8%)	122 (74.8%)
	Yes	226 (37.60%)	185 (42.2%)	41 (25.2%)
Availability of handwashing facility	No	532 (88.52%)	376 (85.8%)	156 (95.7%)
	Yes	69 (11.48%)	62 (14.2%)	7 (4.29%)
Ownership of a kitchen garden	No	153 (25.46%)	100 (22.8%)	53 (32.5%)
	Yes	448 (74.54%)	338 (77.2%)	110 (67.5%)
Farmland size	Landless	432 (71.88%)	315 (71.9%)	117 (71.8%)
	Less than 1 Hectares	42 (6.988%)	31 (7.08%)	11 (6.75%)
	> 1Ha	127 (21.13%)	92 (21.0%)	35 (21.5%)
Milk consumption	Fresh/fermented milk	259 (43.09%)	204 (46.6%)	55 (33.7%)
	No milk	342 (56.91%)	234 (53.4%)	108 (66.3%)

¹Mean [Standard Deviation]; ²Total number (percentage per column).

Table S3 Descriptive summary statistics of study variables by district

Study variables	Burera N = 129*	Gakenke N = 130*	Gicumbi N = 145*	Musanze N = 96*	Rulindo N = 101*
Height-for-age z-score	-1.49 (-2.22, -0.66)	-1.36 (-2.09, -0.57)	-1.31 (-2.08, -0.49)	-1.63 (-2.26, -0.86)	-1.25 (-1.97, -0.63)
Stunting Status					
Not stunted	90 (70%)	96 (74%)	108 (74%)	65 (68%)	79 (78%)
Stunted	39 (30%)	34 (26%)	37 (26%)	31 (32%)	22 (22%)
Child's age (months)	18 (9, 26)	16 (8, 23)	17 (8, 26)	16 (9, 28)	21 (13, 27)
Child sex					
Female	63 (49%)	70 (54%)	74 (51%)	45 (47%)	59 (58%)
Male	66 (51%)	60 (46%)	71 (49%)	51 (53%)	42 (42%)
Birth weight (grams)	3100 (2900, 3500)	3100 (2800, 3500)	3300 (3000, 3600)	3200 (3000, 3500)	3100 (2900, 3500)
Underweight status (Yes)	8 (6.2%)	10 (7.7%)	4 (2.8%)	13 (14%)	6 (5.9%)
Twin or Triplet	6 (4.7%)	9 (6.9%)	9 (6.2%)	10 (10%)	5 (5.0%)
Not currently breastfeeding	36 (28%)	25 (19%)	36 (25%)	24 (25%)	24 (24%)
Days a child was left alone	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 3.00)	0 (0, 2)
Growth monitoring frequency	4 (3, 6)	5 (3, 6)	3 (2, 5)	4 (2, 5)	3 (2, 5)
Maternal food support (No)	42 (33%)	40 (31%)	69 (48%)	29 (30%)	30 (30%)
Maternal emotional support (No)	29 (22%)	27 (21%)	48 (33%)	20 (21%)	10 (9.9%)
Handwashing facility (No)	123 (95%)	117 (90%)	126 (87%)	90 (94%)	76 (75%)
Access to electricity (No)	69 (53%)	101 (78%)	84 (58%)	59 (61%)	62 (61%)
Ownership of a kitchen garden (No)	36 (28%)	19 (15%)	38 (26%)	40 (42%)	20 (20%)
Farmland larger than 1 Ha (Yes)	30 (23%)	33 (25%)	31 (21%)	19 (20%)	14 (14%)
Milk consumption (No)	82 (64%)	96 (74%)	74 (51%)	50 (52%)	40 (40%)

*Median (Quartile 1, Quartile 3) for continuous variables; Total number (percentage per column). for categorical variables

b. Maps of predicted values and residual spatial patterns (from GWR and MGWR models)

The figure below provides additional spatial context to the main manuscript results (Section 3.4), illustrating how predictions and residual patterns differ between the GWR and MGWR models.

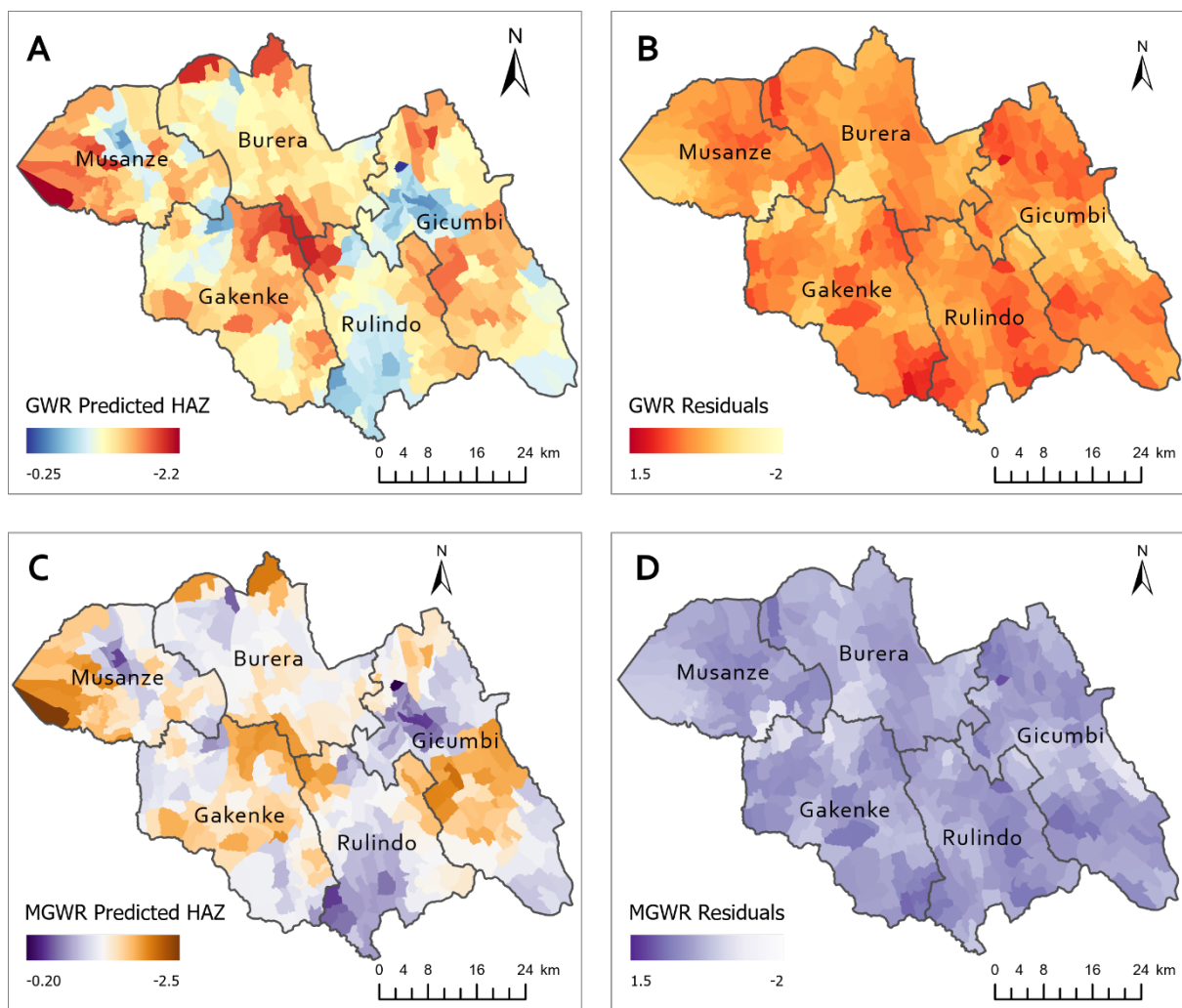


Figure S2 Spatial distributions of predicted HAZ scores and residuals for the GWR and MGWR models. (a) Predicted HAZ by GWR; (b) GWR residuals; (c) Predicted HAZ by MGWR; (d) MGWR residuals. Darker shades indicate higher residual values, highlighting spatial variability in model performance across the study area.