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The Impact of Land Degradation on Food Productivity

Case studies of Uruguay, Argentina and Kenya

Volume 2: Appendices

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V.W.P. van Engelen

riivm research for man and environment

UNEP

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF MAPS

Argentina

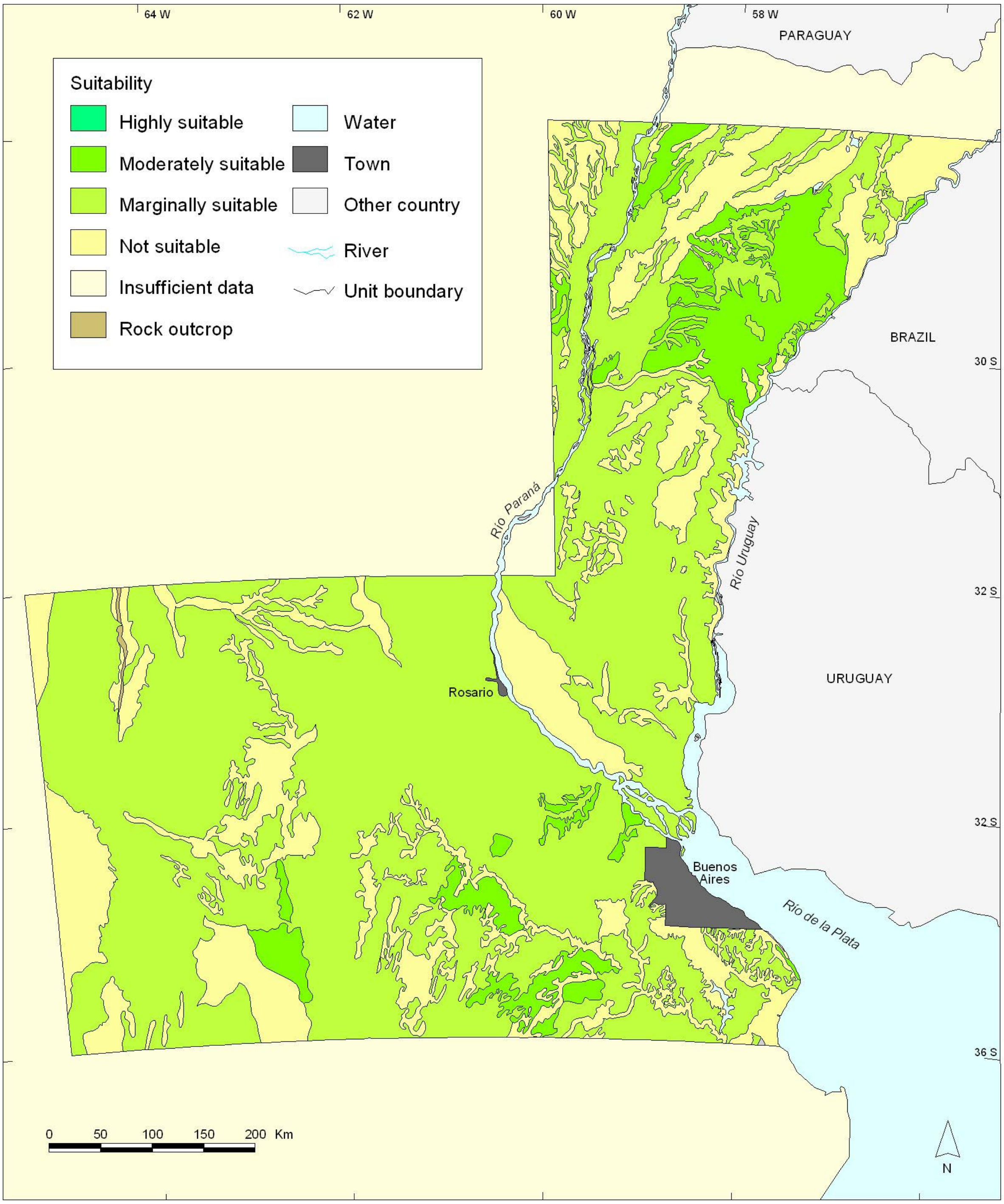
Kenya

APPENDICES

Appendix 1: Maps of Argentina

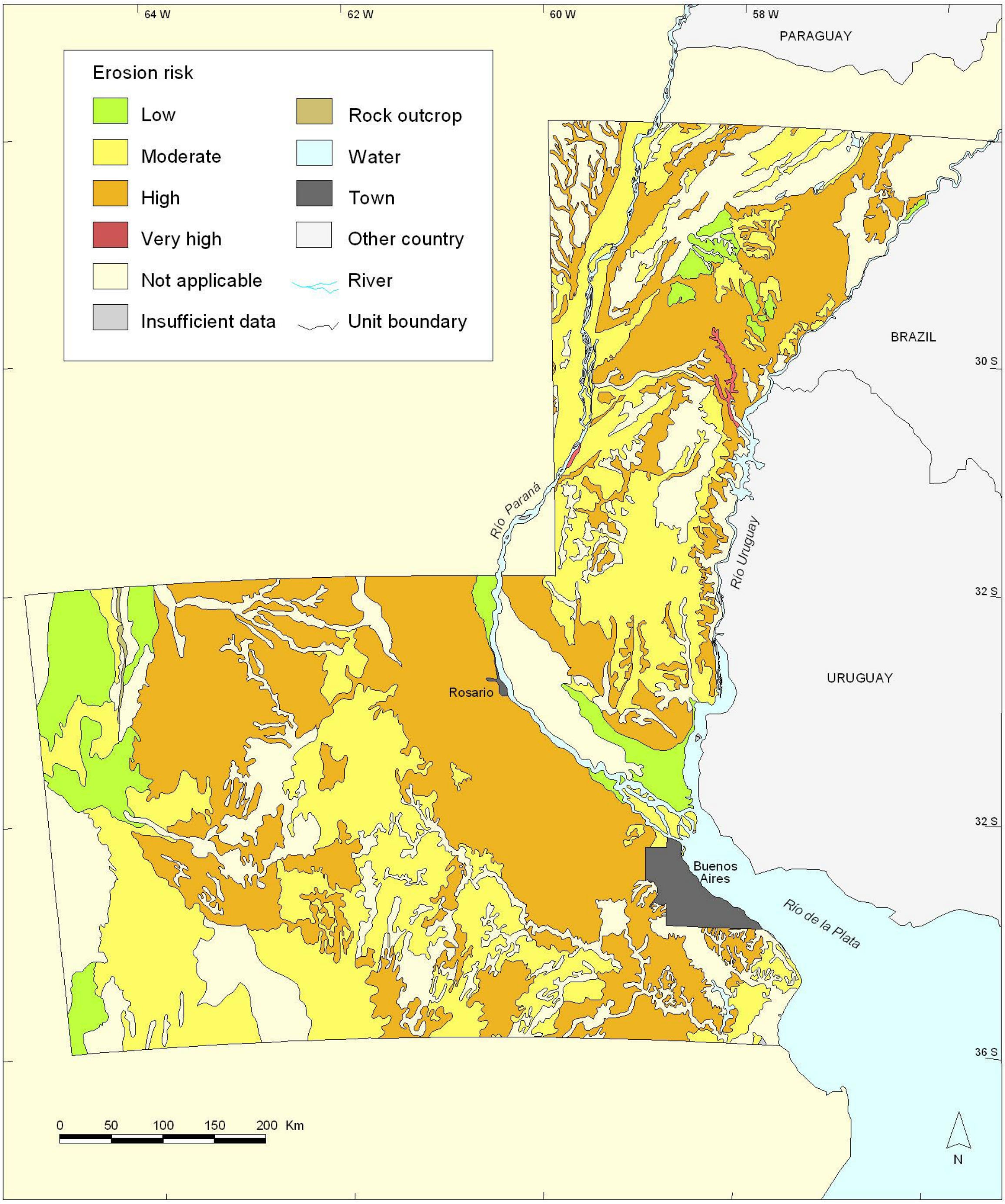
1 Suitability for wheat
2 Erosion risk under wheat
3 Loss of topsoil after simulated 20 years of soil erosion
4 Constraint-free wheat yield
5 Potential water-limited wheat yield
6 Relative water-limited wheat yield
7 Potential nutrient-limited wheat yield
8 Relative nutrient-limited wheat yield
9 Potential water-limited wheat yield after simulated 20 years of soil erosion
10 Relative water-limited wheat yield after simulated 20 years of soil erosion
11 Potential nutrient-limited wheat yield after simulated 20 years of soil erosion
12 Relative nutrient-limited wheat yield after simulated 20 years of soil erosion

SUITABILITY FOR WHEAT



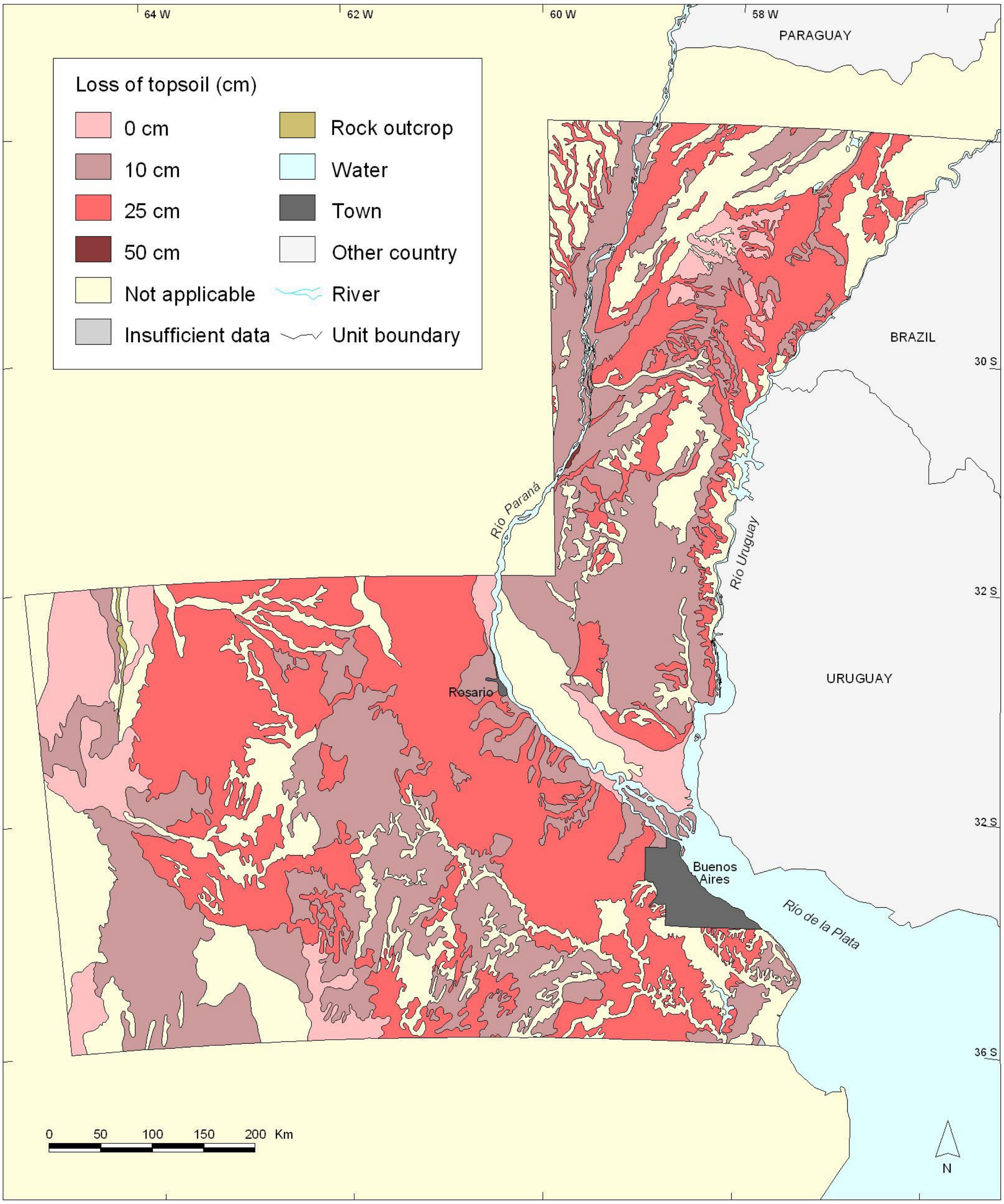
Map 1.

EROSION RISK UNDER WHEAT



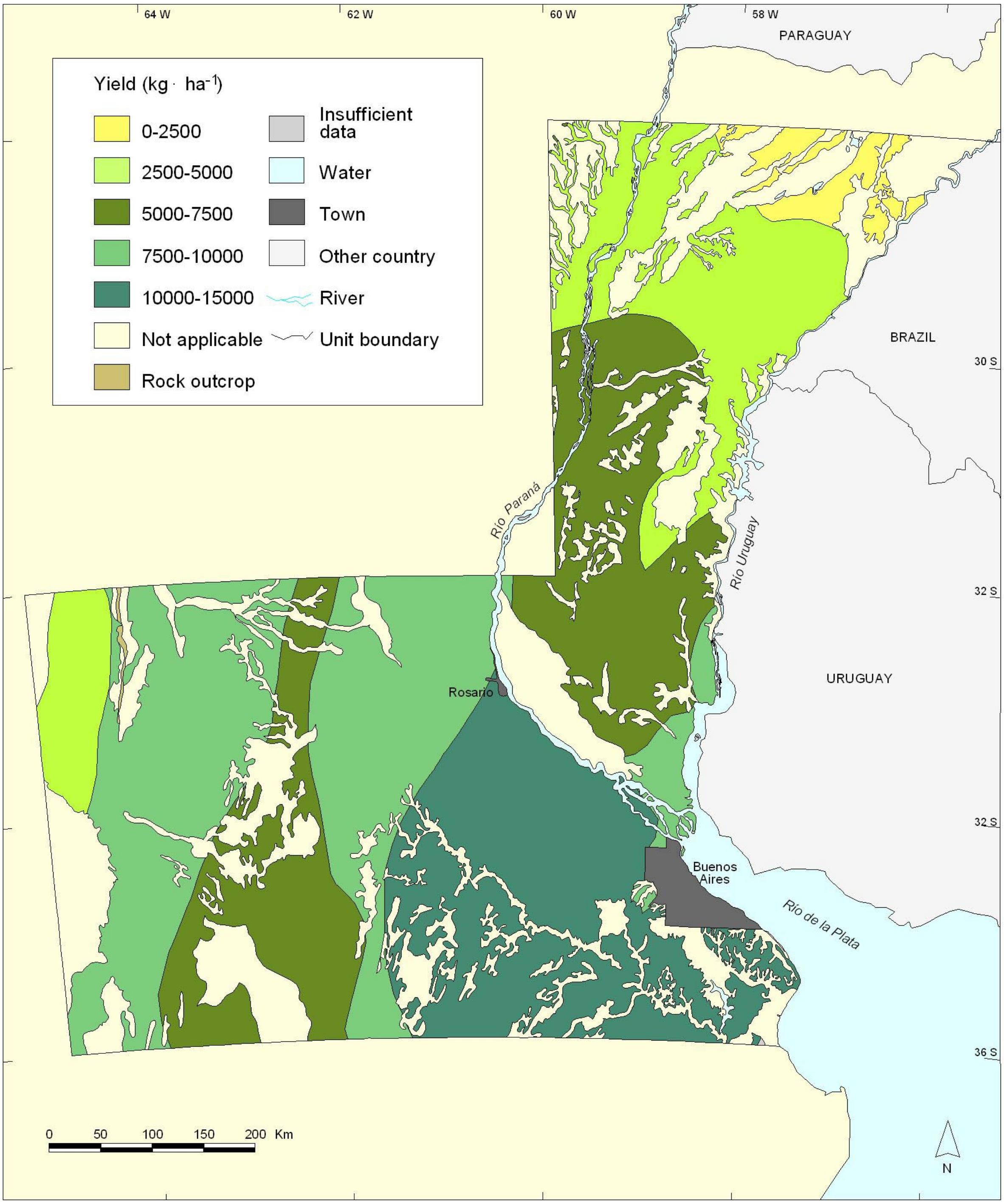
Map 2.

LOSS OF TOPSOIL after simulated 20 years of soil erosion



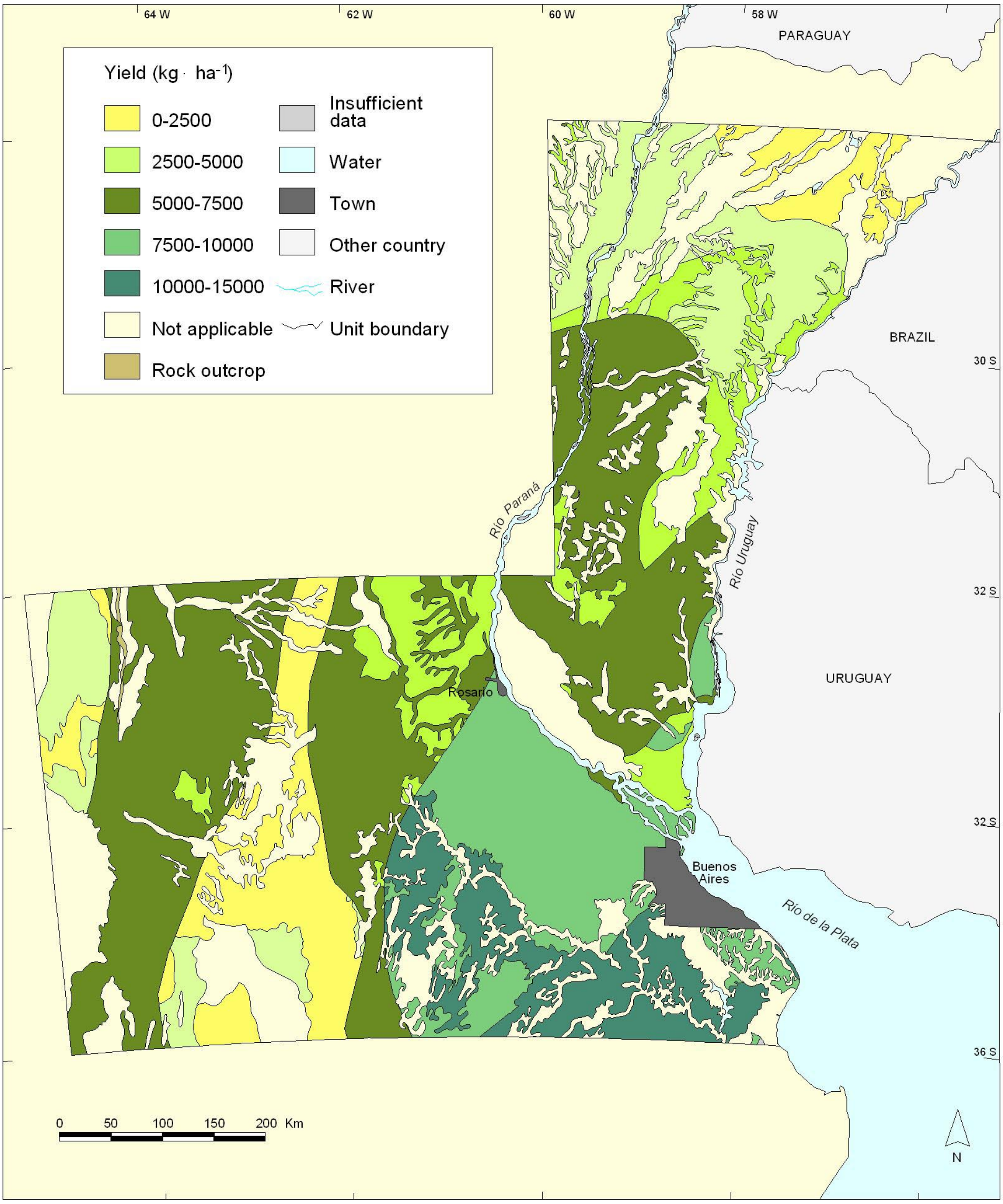
Map 3.

CONSTRAINT-FREE WHEAT YIELD



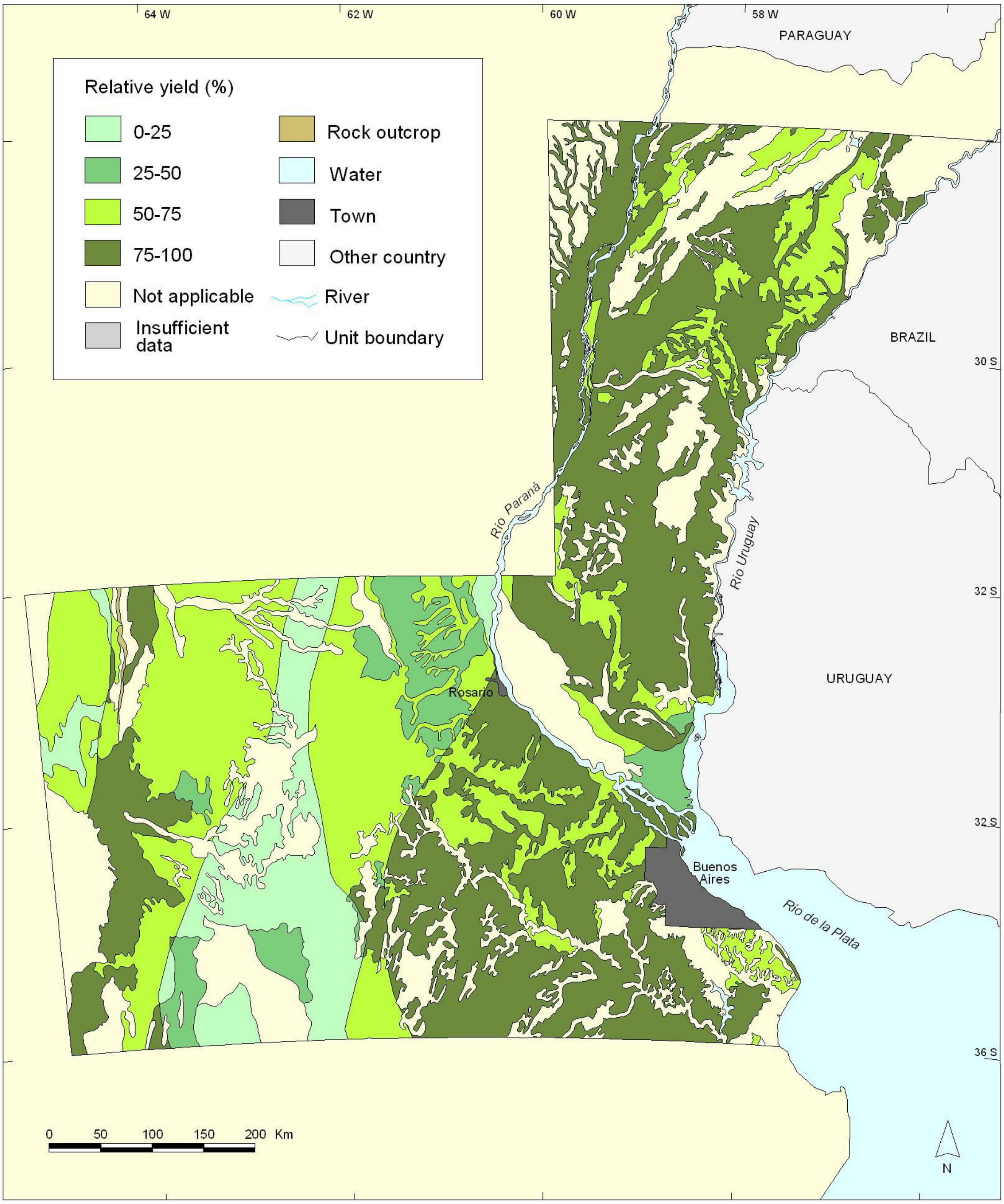
Map 4.

POTENTIAL WATER-LIMITED WHEAT YIELD



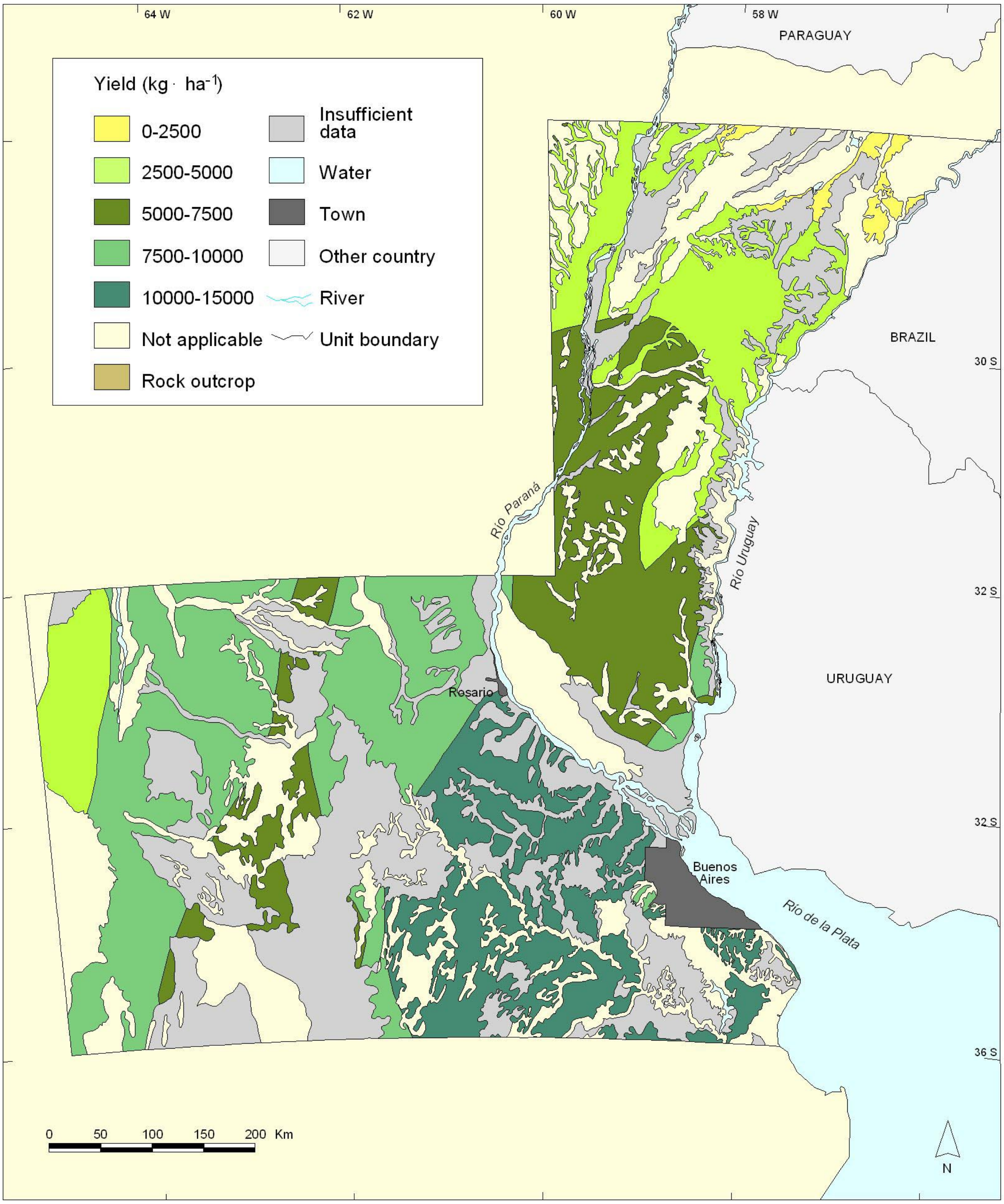
Map 5.

RELATIVE WATER-LIMITED WHEAT YIELD



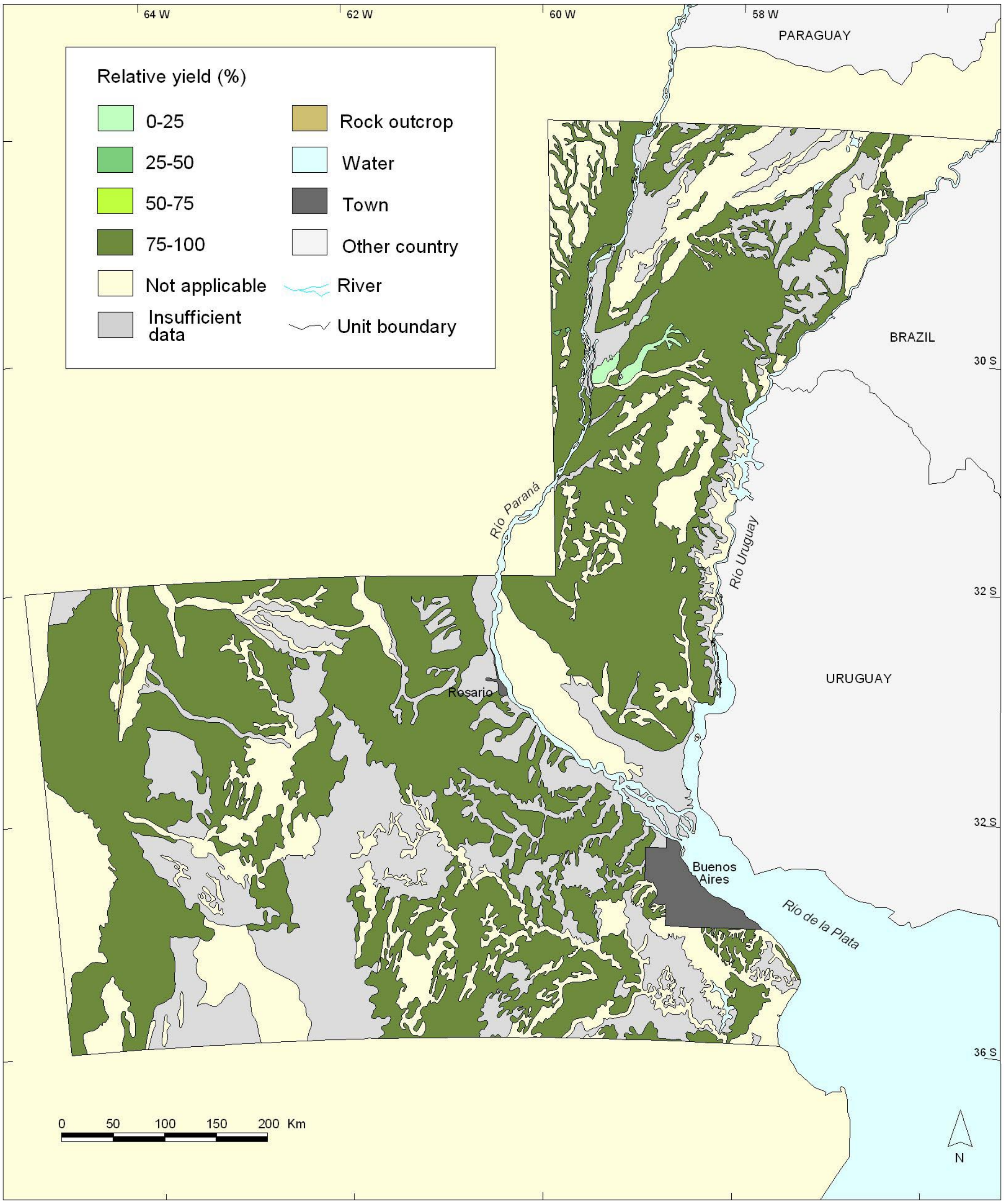
Map 6.

POTENTIAL NUTRIENT-LIMITED WHEAT YIELD



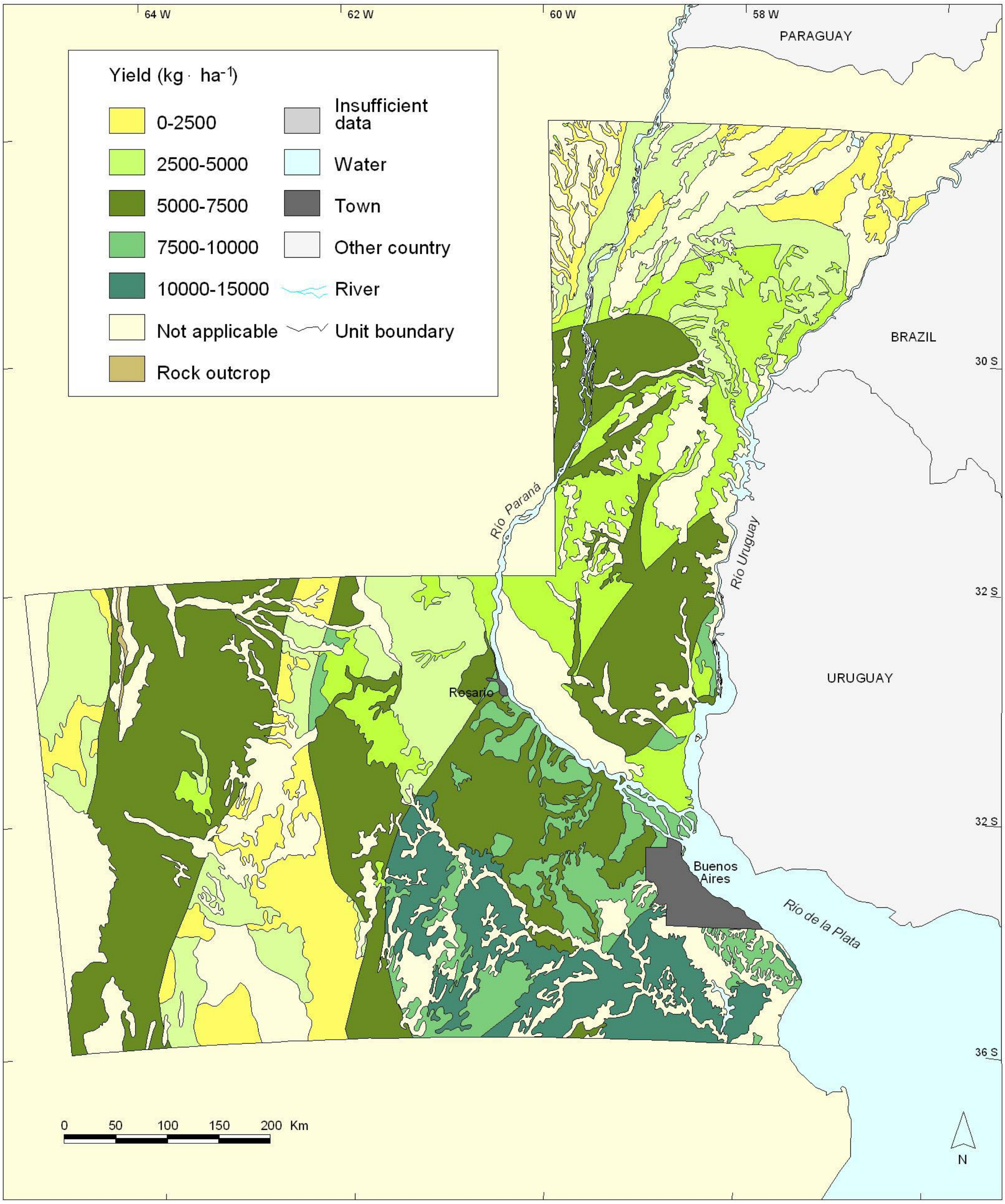
Map 7.

RELATIVE NUTRIENT-LIMITED WHEAT YIELD



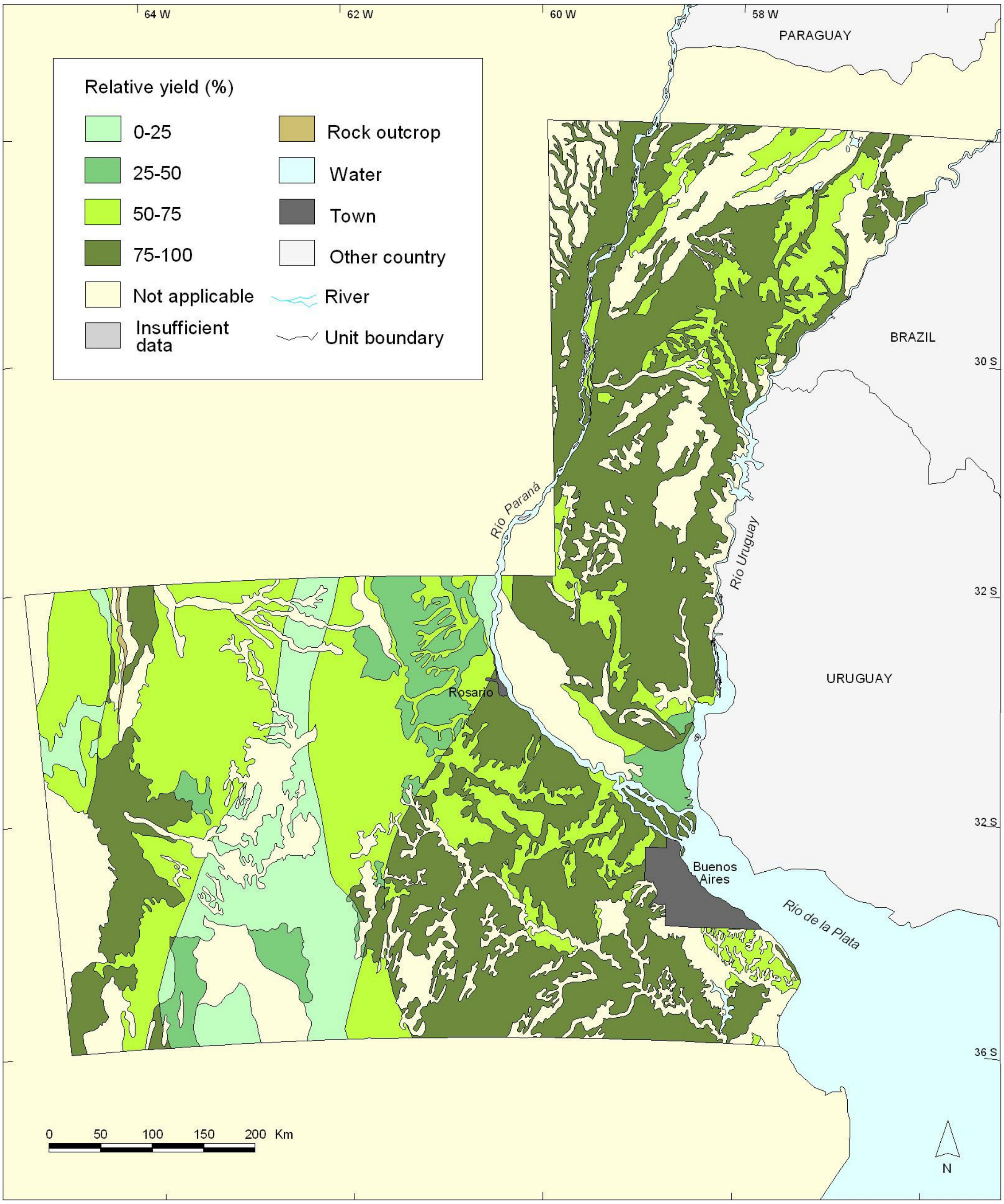
Map 8.

POTENTIAL WATER-LIMITED WHEAT YIELD after simulated 20 years of soil erosion



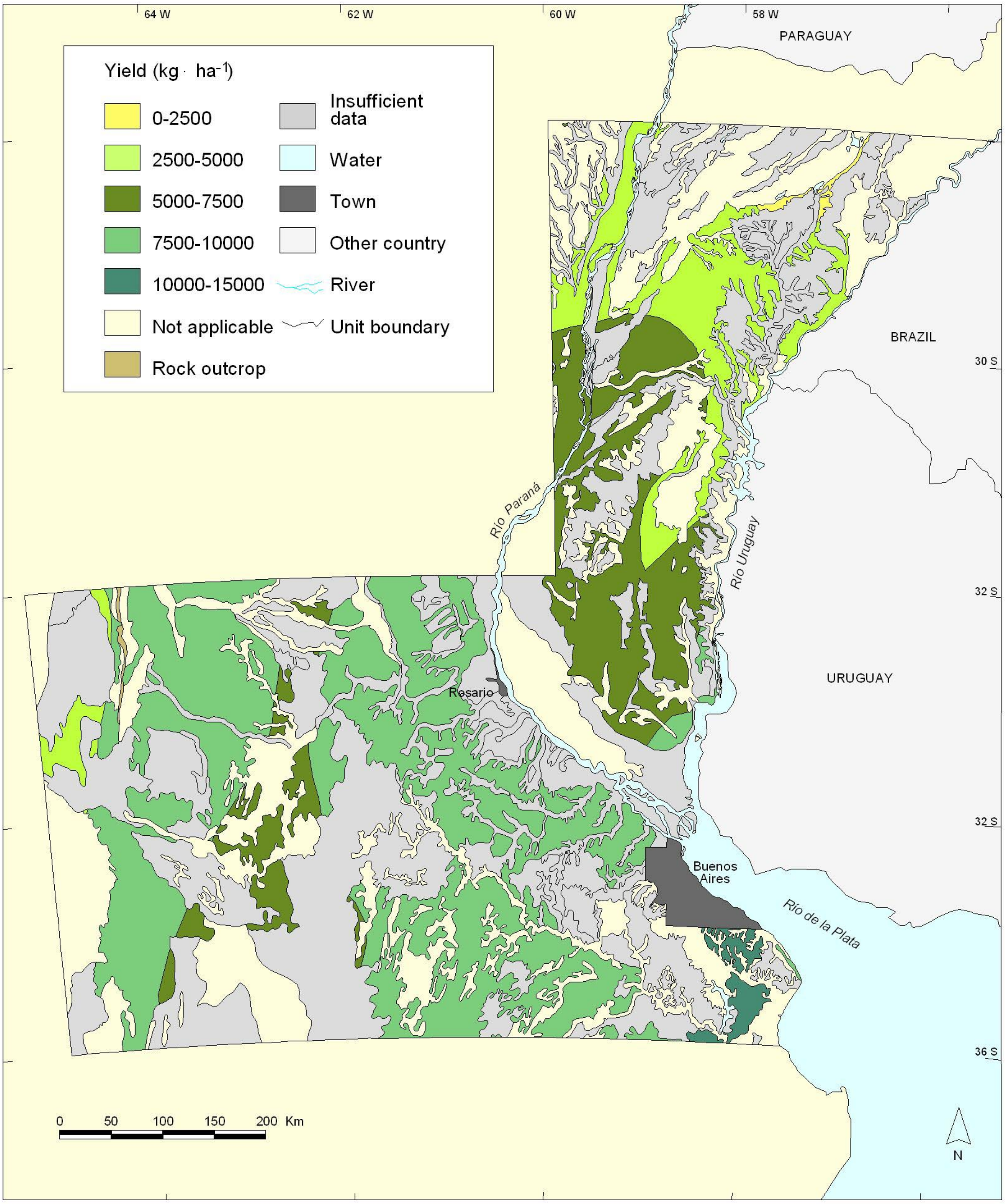
Map 9.

RELATIVE WATER-LIMITED WHEAT YIELD after simulated 20 years of soil erosion



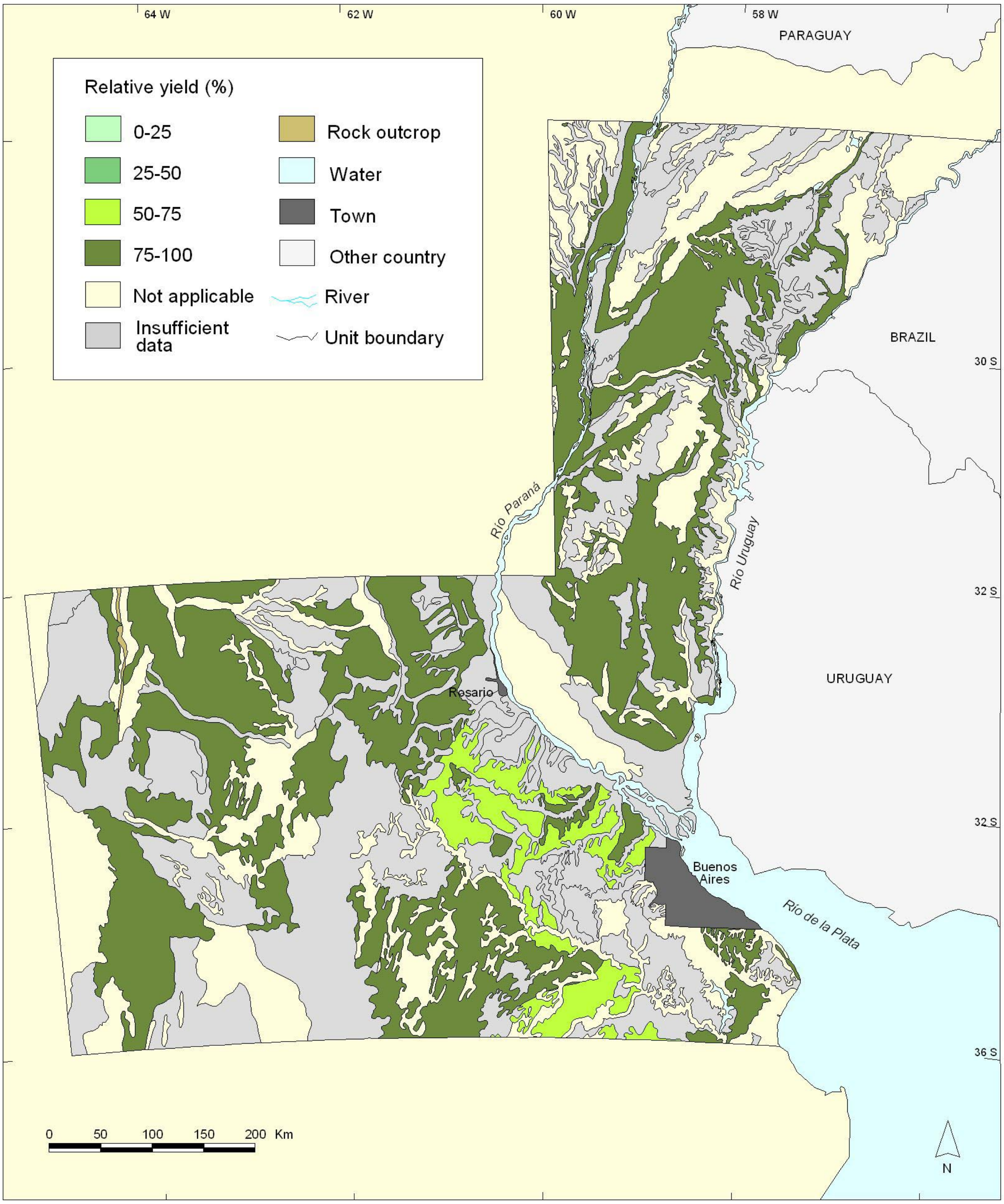
Map 10.

POTENTIAL NUTRIENT-LIMITED WHEAT YIELD after simulated 20 years of soil erosion



Map 11.

RELATIVE NUTRIENT-LIMITED WHEAT YIELD after simulated 20 years of soil erosion



Map 12.

Appendix 2: Maps of Kenya

1 Suitability for maize
2 Erosion risk under maize
3 Loss of topsoil after simulated 20 years of soiL erosion
4 Constraint-free maize yield
5 Potential water-limited maize yield
6 Relative water-limited maize yield
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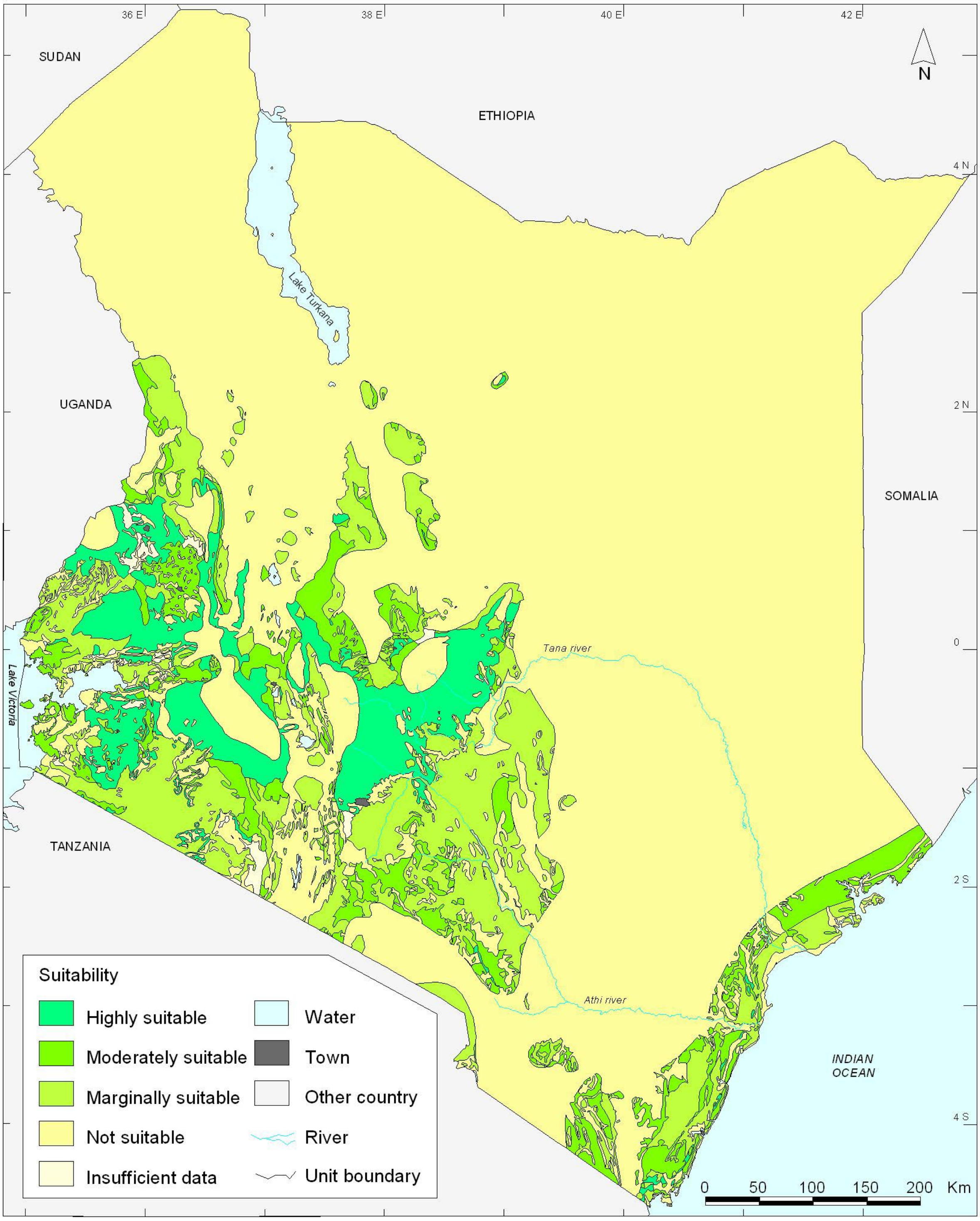
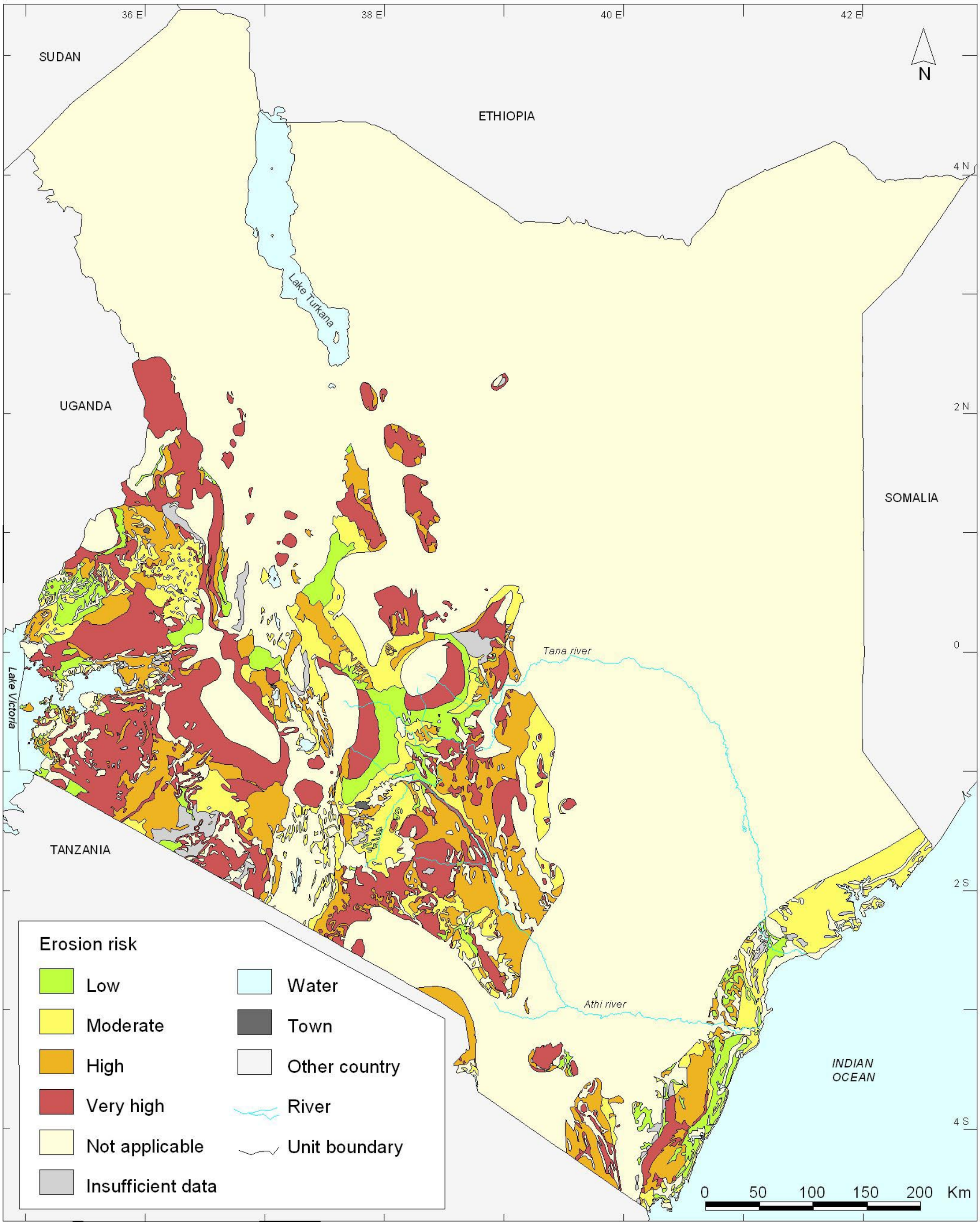
12 Relative nutrient-limited maize yield after simulated 20 years of soil erosion
13 Soil components with estimated data

SUITABILITY FOR MAIZE



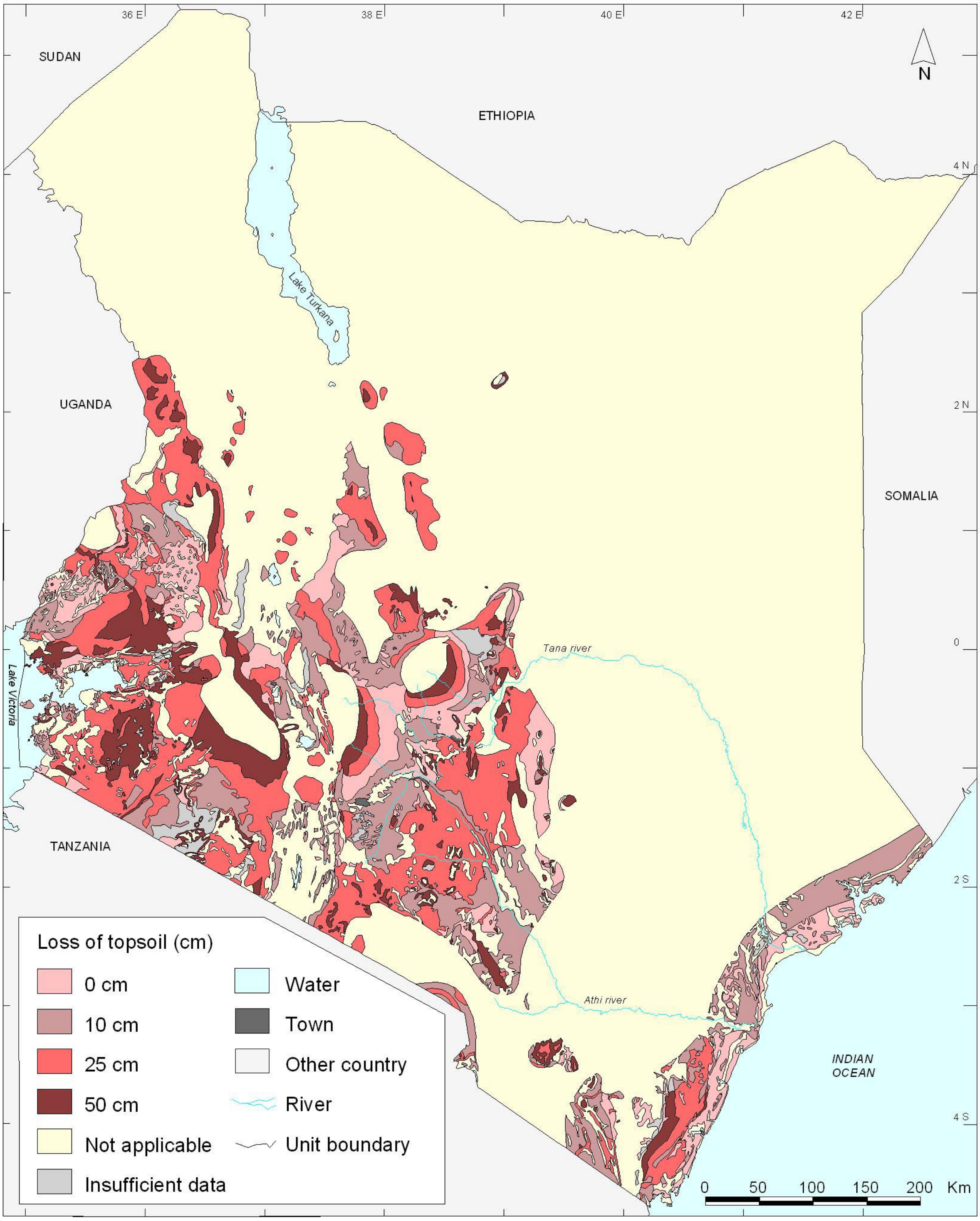
Map 1.

EROSION RISK UNDER MAIZE

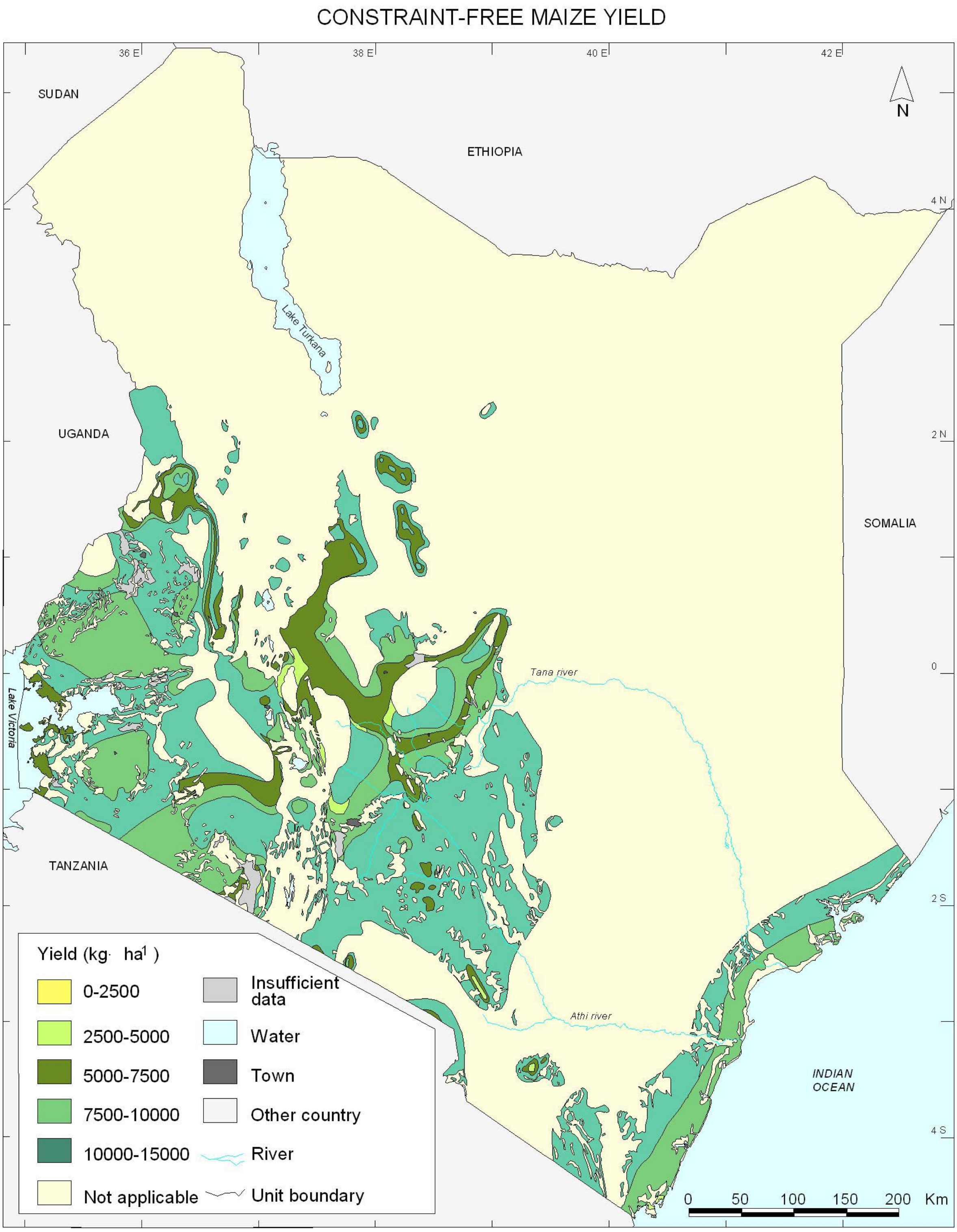


Map 2.

LOSS OF TOPSOIL after simulated 20 years of soil erosion

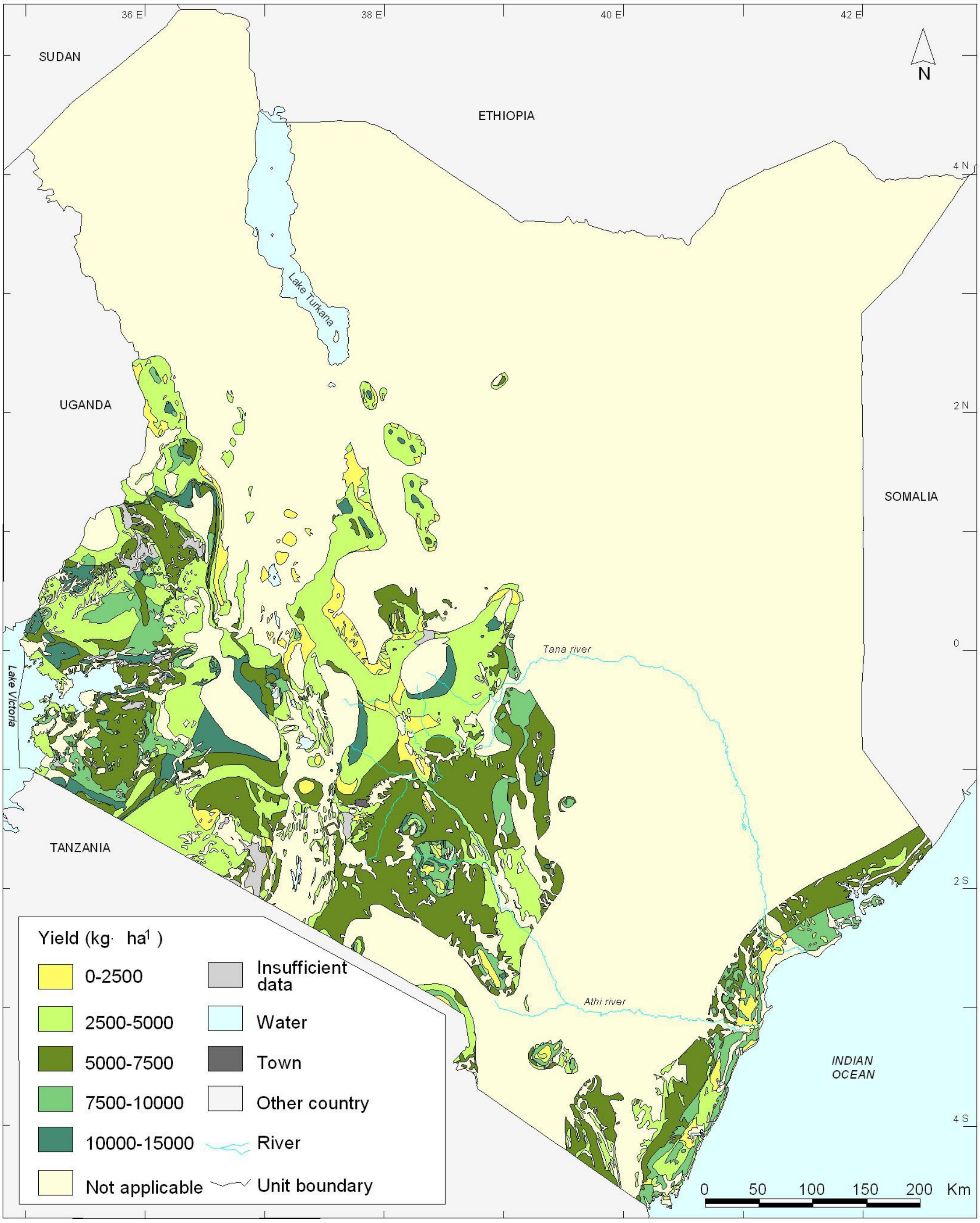


Map 3.

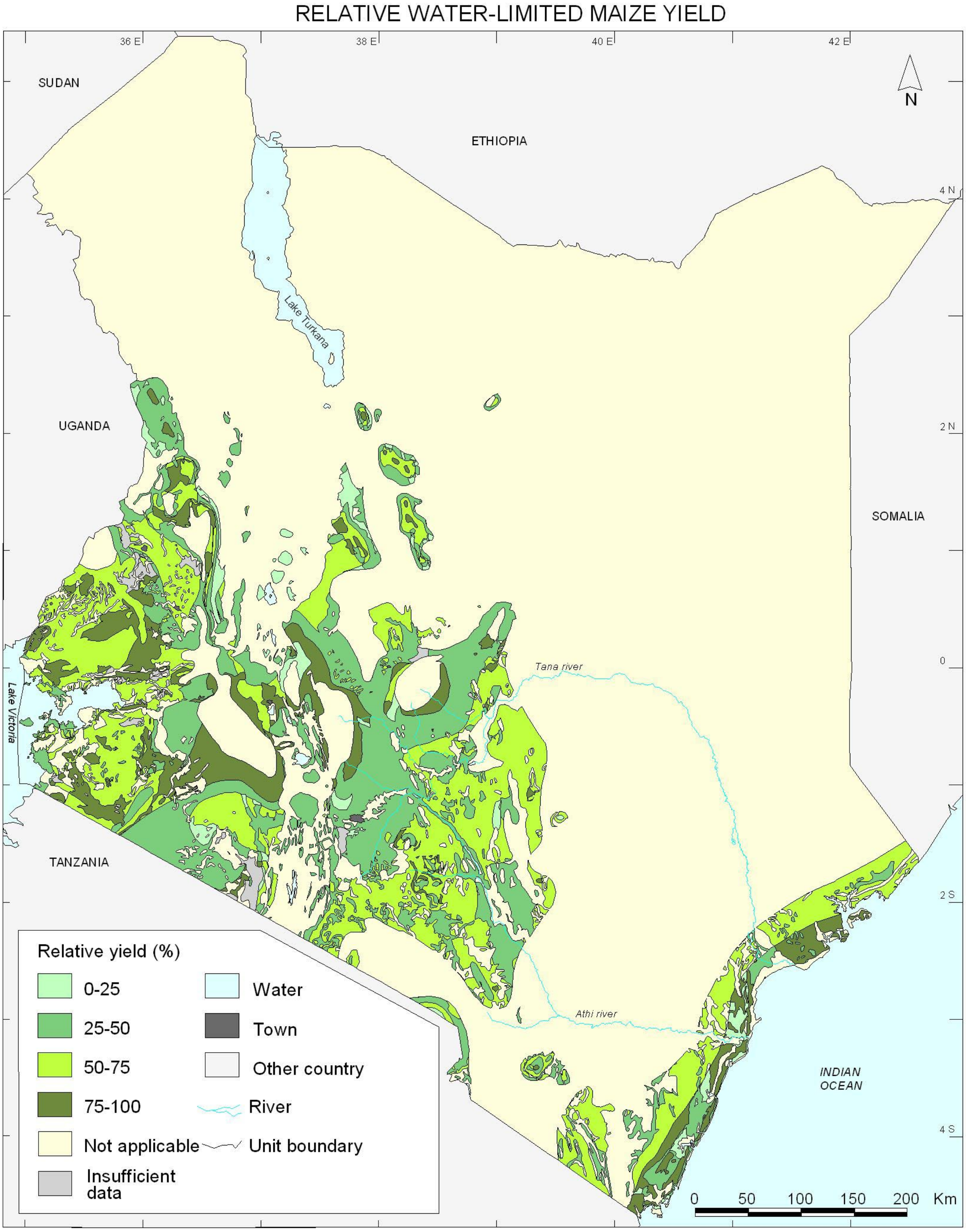

CONSTRAINT-FREE MAIZE YIELD
36 E
38 E
40 E
42 E
4 N
2 N
0
2 S
4 S
N
SUDAN
ETHIOPIA
UGANDA
SOMALIA
TANZANIA
Lake Turkana
Lake Victoria
Tana river
Athi river
INDIAN OCEAN
Yield (kg· ha-1)
0-2500
2500-5000
5000-7500
7500-10000
10000-15000
Not applicable
Insufficient data
Water
Town
Other country
River
Unit boundary
0 50 100 150 200 Km

Map 4.

POTENTIAL WATER-LIMITED MAIZE YIELD

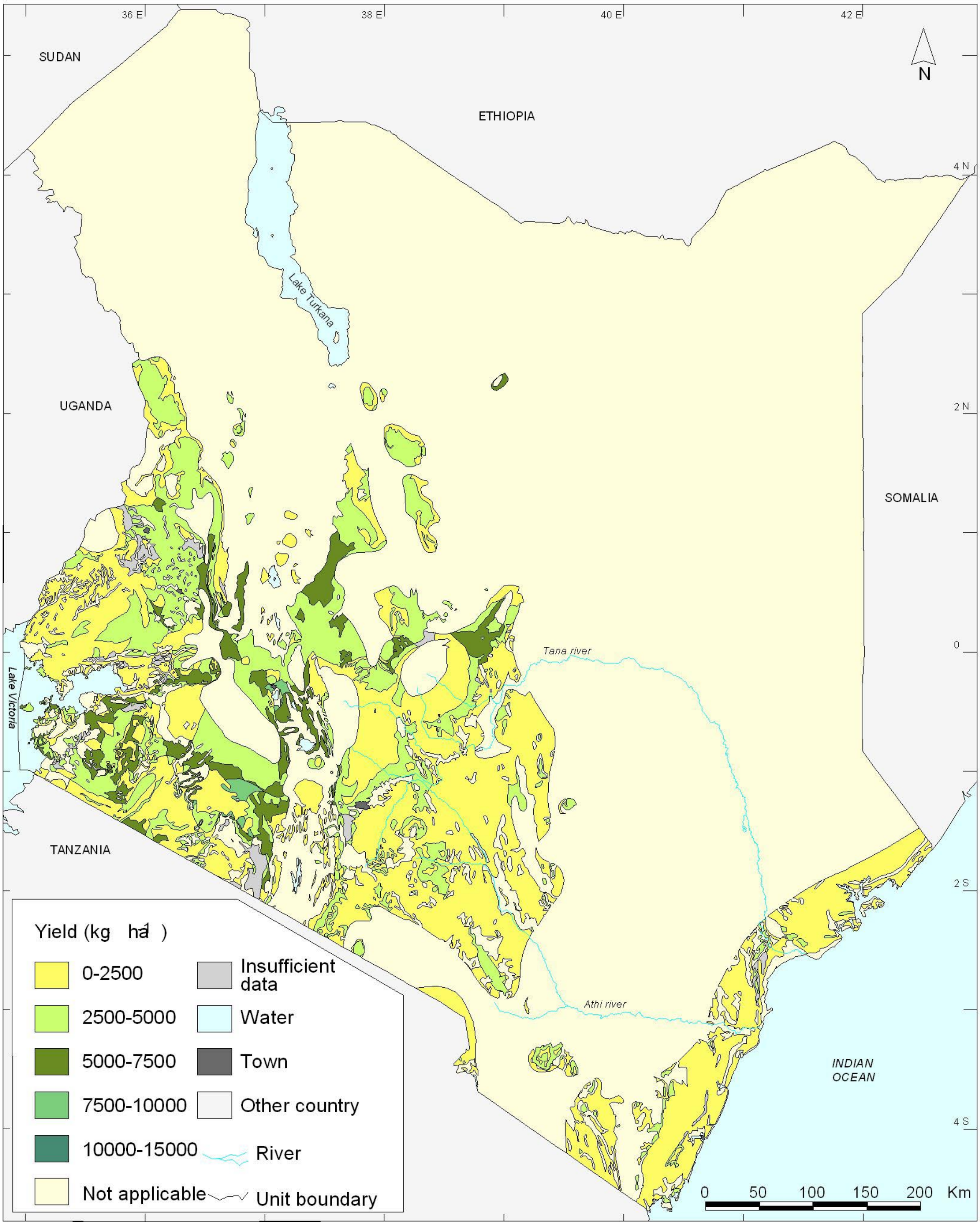


Map 5.


RELATIVE WATER-LIMITED MAIZE YIELD
36 E
38 E
40 E
42 E
N
4 N
2 N
0
2 S
4 S
SUDAN
ETHIOPIA
UGANDA
SOMALIA
TANZANIA
INDIAN OCEAN
Lake Turkana
Lake Victoria
Tana river
Athi river
Relative yield (%)
0-25
25-50
50-75
75-100
Not applicable
Insufficient data
Water
Town
Other country
River
Unit boundary
0 50 100 150 200 Km

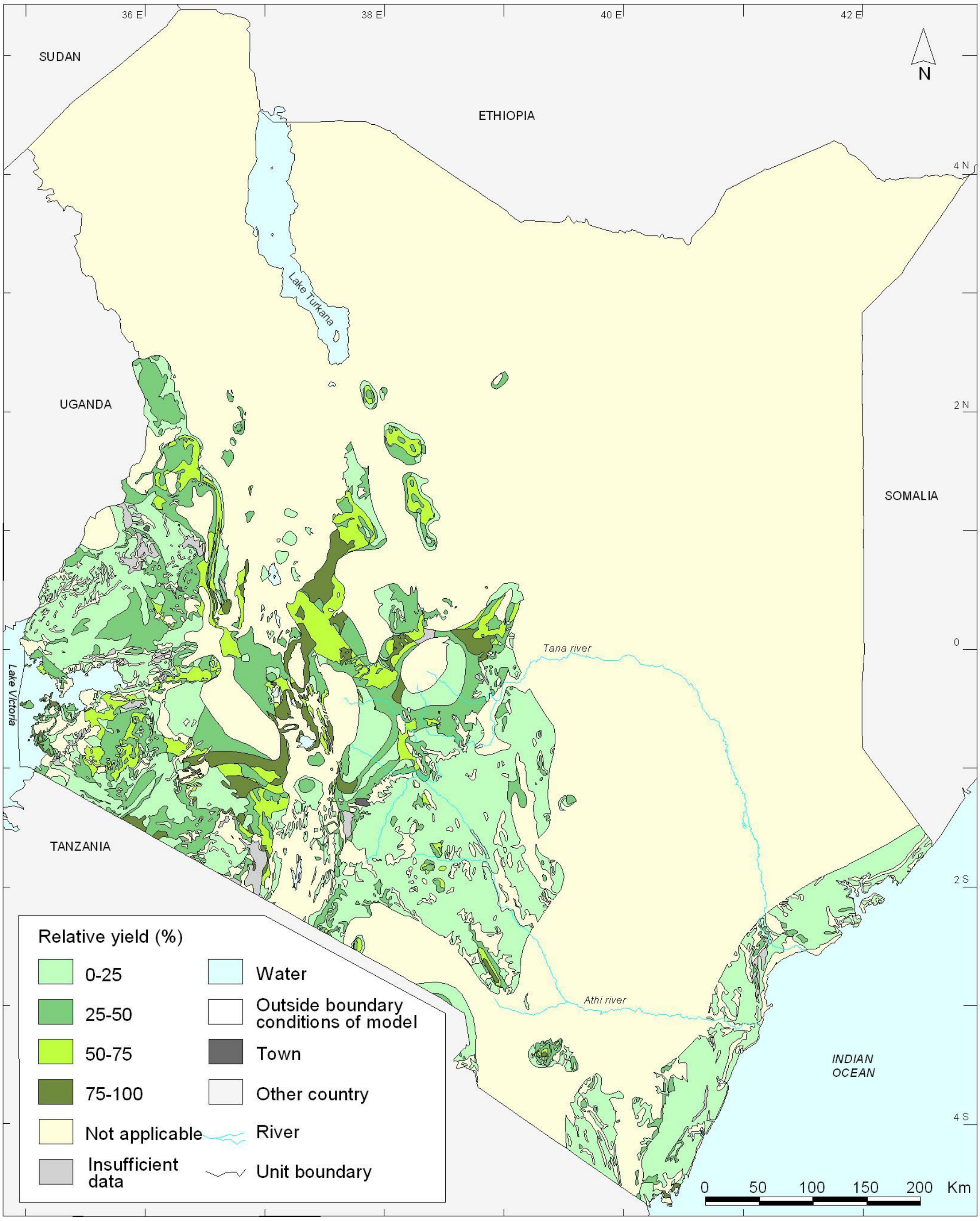
Map 6.

POTENTIAL NUTRIENT-LIMITED MAIZE YIELD



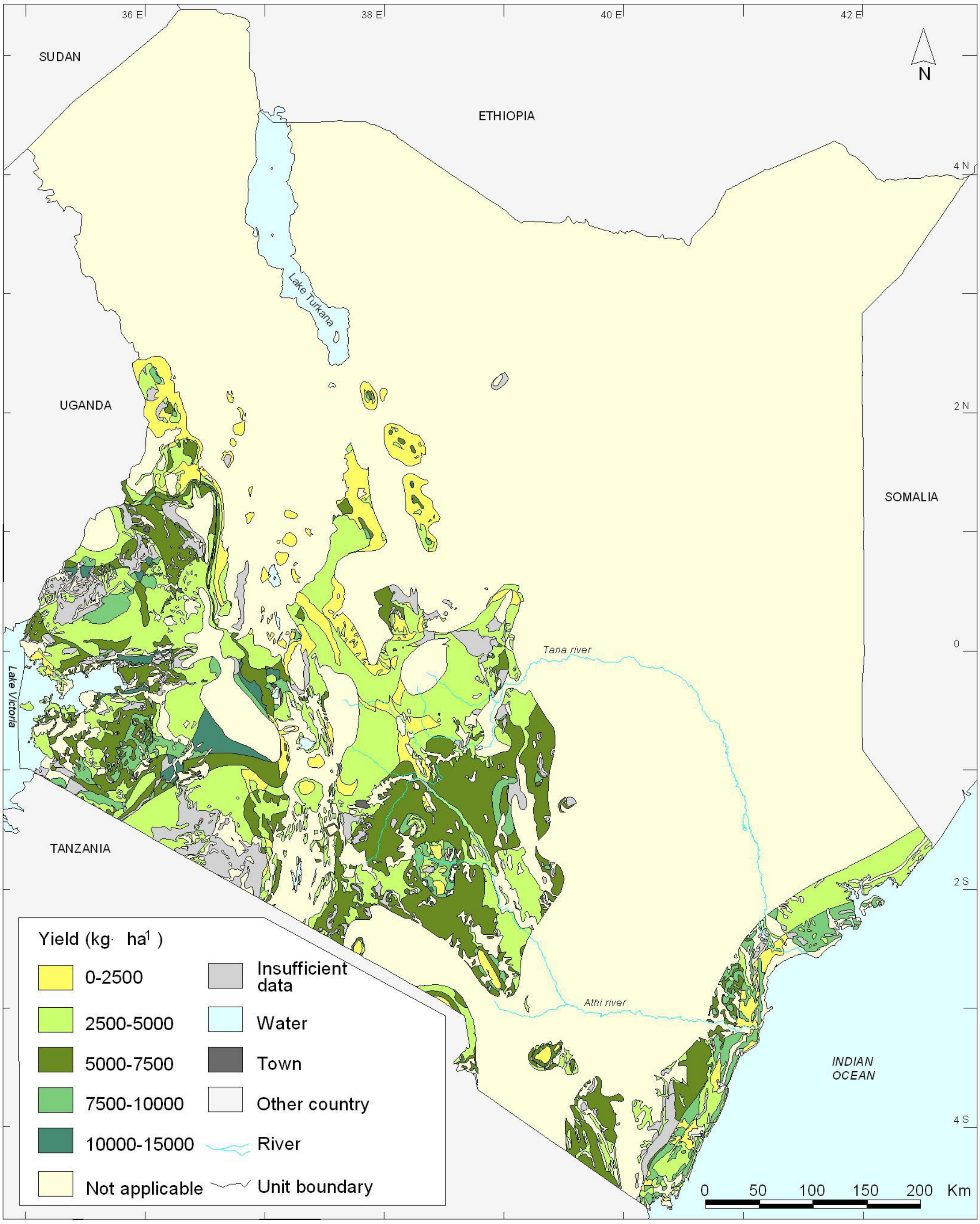
Map 7.

RELATIVE NUTRIENT-LIMITED MAIZE YIELD



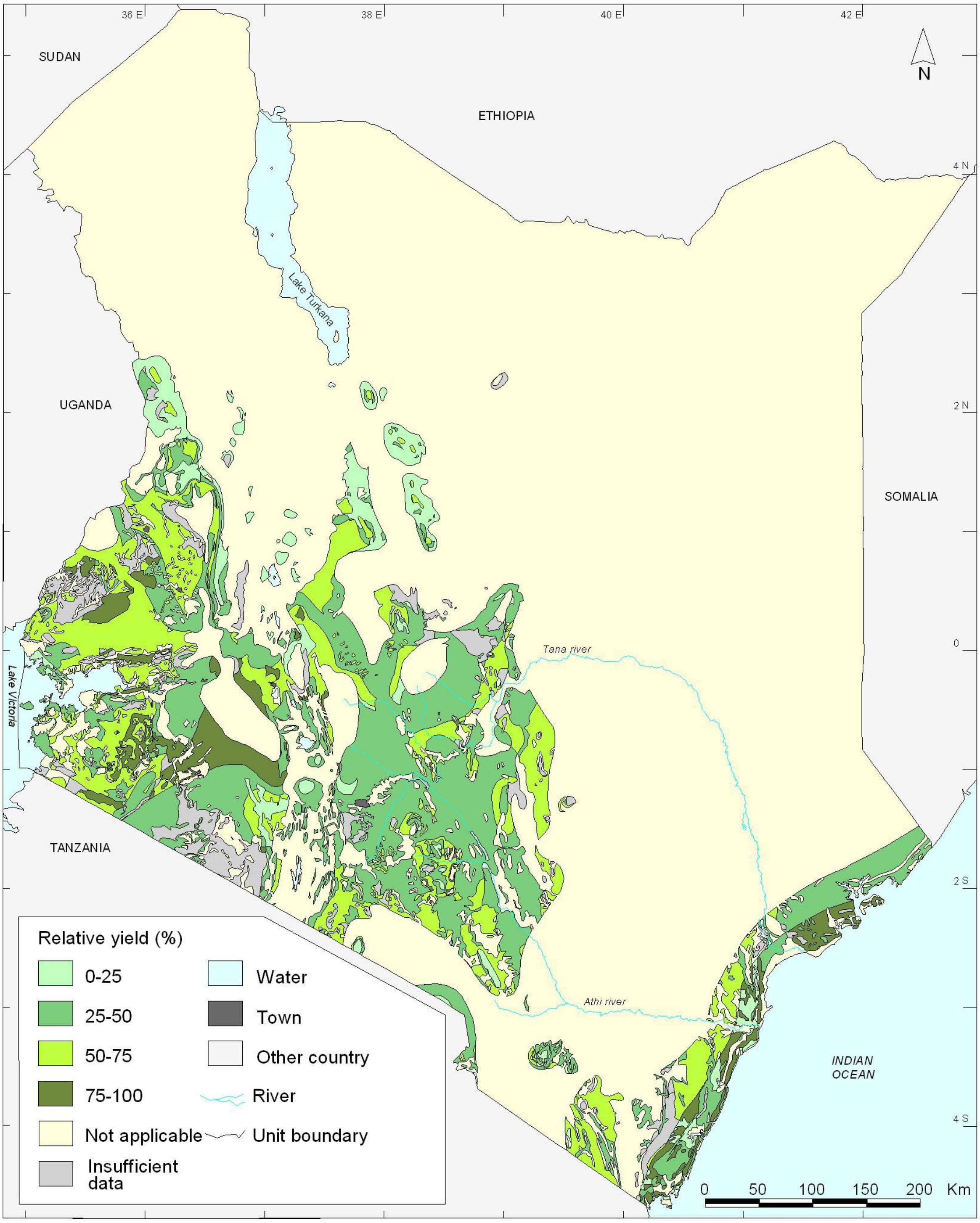
Map 8.

POTENTIAL WATER-LIMITED MAIZE YIELD after simulated 20 years of soil erosion



Map 9.

RELATIVE WATER-LIMITED MAIZE YIELD after simulated 20 years of soil erosion



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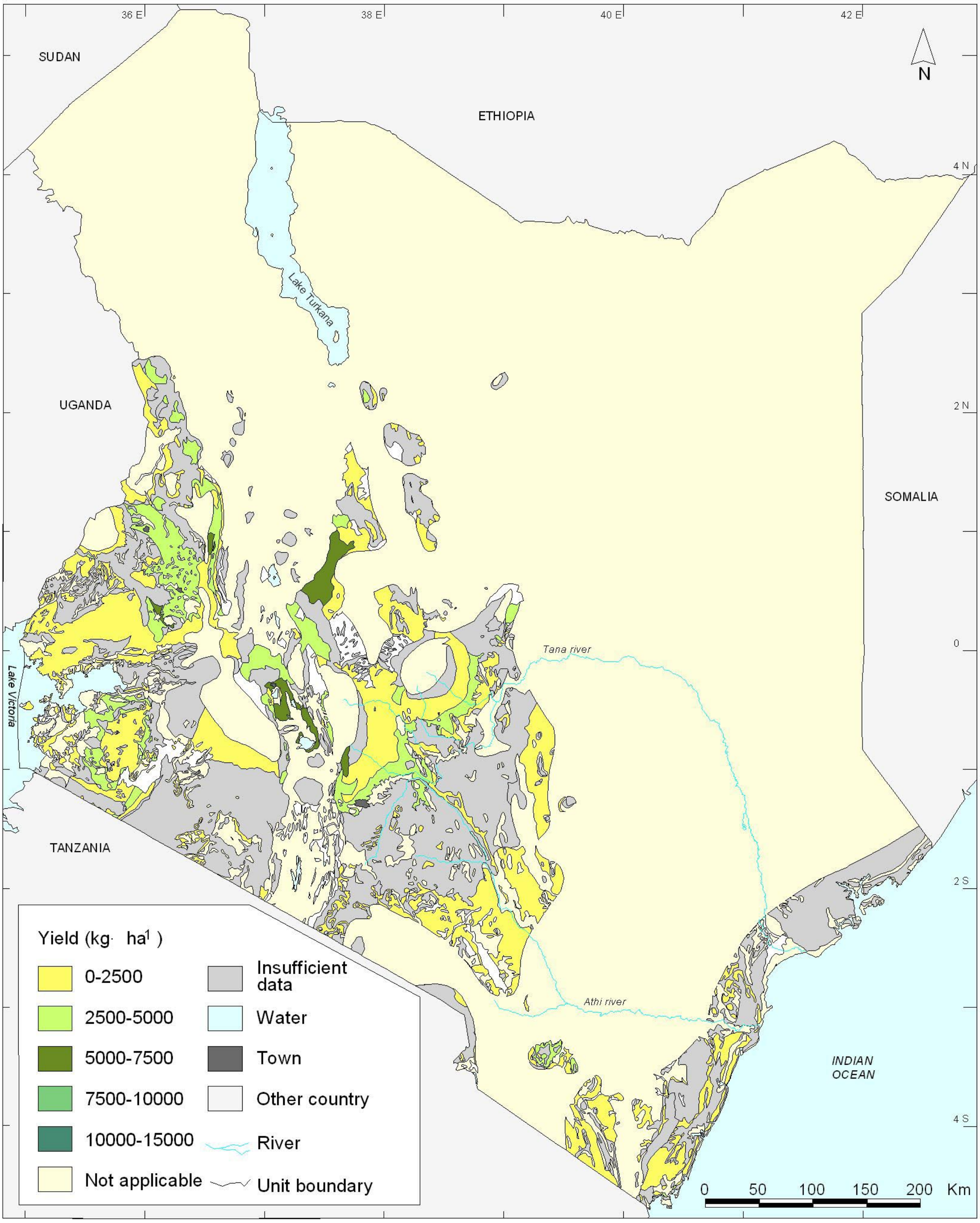
POTENTIAL NUTRIENT-LIMITED MAIZE YIELD after simulated 20 years of soil erosion



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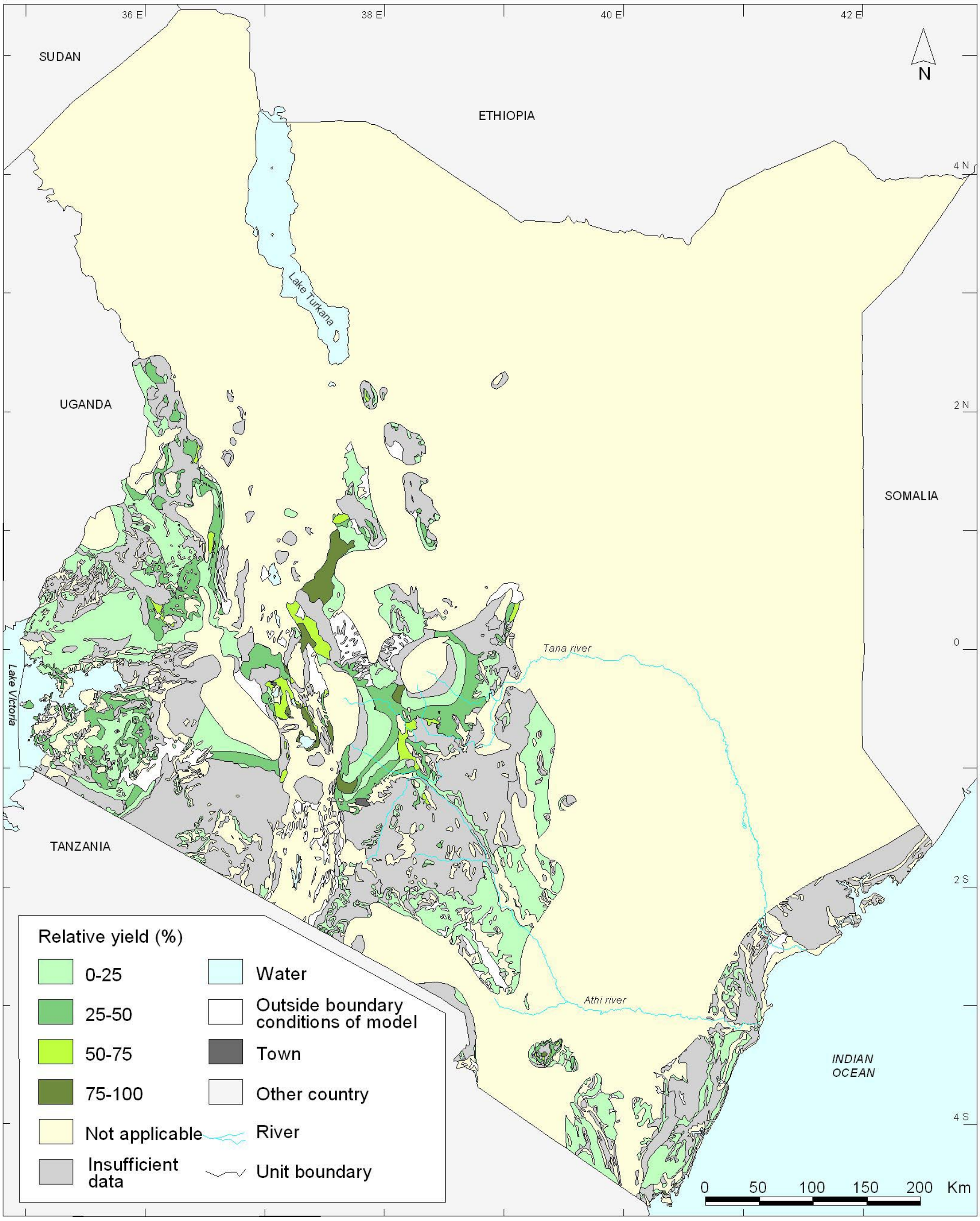
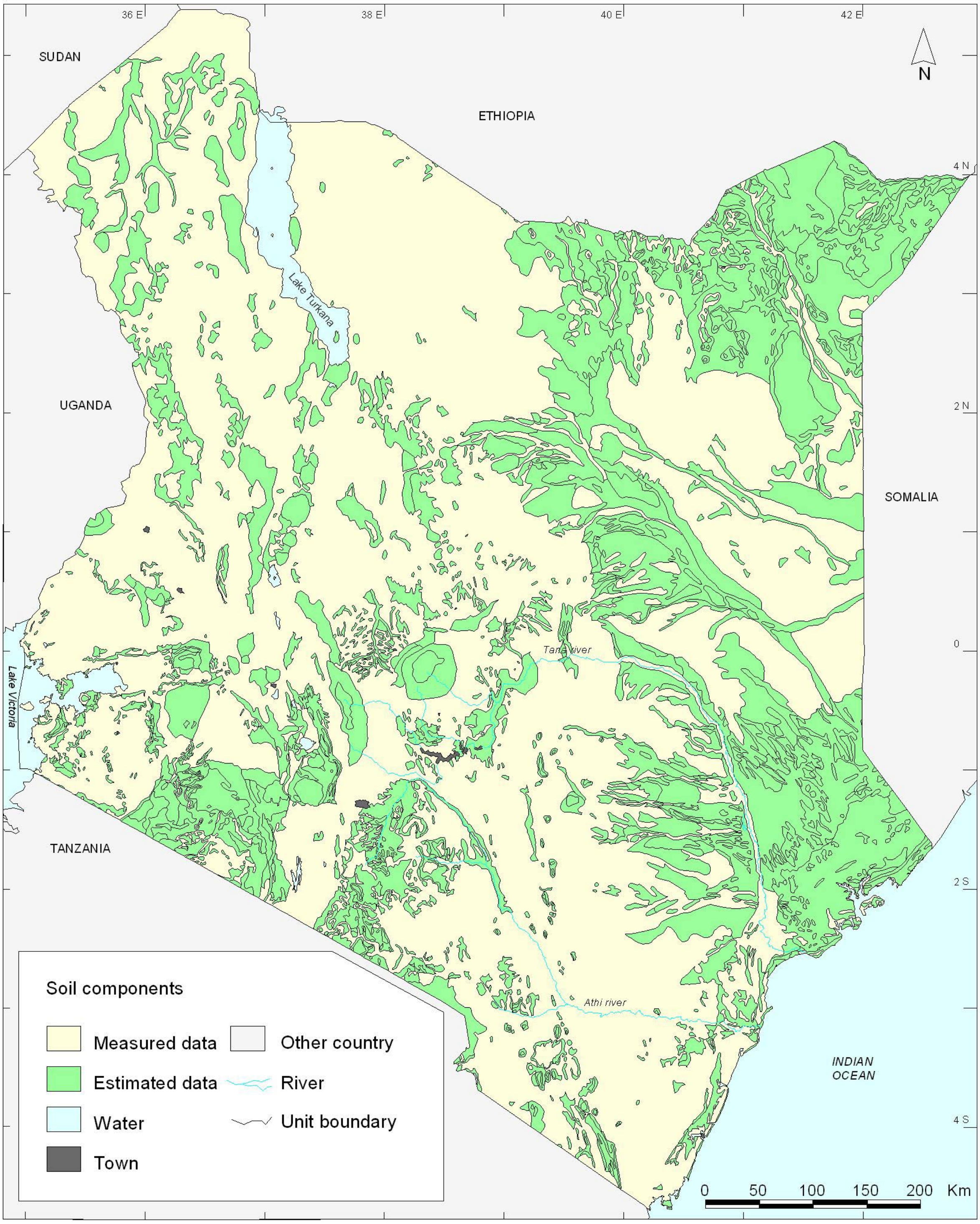
RELATIVE NUTRIENT-LIMITED MAIZE YIELD after simulated 20 years of soil erosion



Map 12.

SOIL COMPONENTS WITH ESTIMATED DATA



Map 13.

Appendix 3: Pedo-Transfer Function Development

1 Bulk density using SOTER data of Kenya

A Pedo-Transfer Function (PTF) was developed on the basis of measured bulk density values and texture data in the SOTER database of Kenya (KENSOTER). This PTF was used to fill the gaps for bulk density in the same database. The ranges in the KENSOTER database for measured bulk density and sand and clay contents are given in table 1.

Table 1. Ranges of bulk density and their texture.

	sand%	Silt%	clay%	B.D.	N
mean	39.4	20.6	40.6	1.3	181
median	36.0	16.0	41.0	1.3	181
min	2	0	4	0.95	181
max	96	72	86	1.80	181

B.D.= Bulk density ($kg.dm^{-3}$); N= number of samples

Table 2. Means and standard deviation of selected samples.

	Mean	std	N
sand%	39.4	24.5	181
clay%	40.6	20.6	181
B.D.	1.3	0.2	181

B.D.= Bulk density ($kg.dm^{-3}$); N= number of samples

Table 3. Standard error of coefficients.

	Beta	std. error of Beta	B	st. error of B	P-level
sand%	0.581590	0.013761	0.016456	0.000389	0.0000
clay%	0.536607	0.013761	0.015458	0.000396	0.0000

R = 0.9883
R^2 = 0.9767
adj. R^2 = 0.9766
$F(2,179)$ = 37680
p < 0.001

The general formula is as follows:

$$Y = bX + cZ$$

In which:

Y = predicted bulk density
b, c = the Beta values for sand and clay
X,Z = sand and clay percentages

For soils with silt contents higher than 40-50% often too low bulk density values were predicted. Predicted bulk density values < 0.95 were excluded and samples with sum of sand, silt and clay < 98% or > 103% were not used for estimation of bulk density. For those units, and for the units for which no texture data were available, bulk density values were taken from the WISE subset, based on taxonomic units. Some soils with high silt content were Luvic Phaeozems, Eutric Fluvisol, Chromic Fluvisol and Eutric Cambisol. The units that had no textural data were: some Ferralsols, Nitisols and a Vertisol.

2 Continuous PTFs for the estimation bulk density

Introduction

Bulk density data are seldom measured on a routine basis during soil surveys and as such are often under-represented in databases, including the WISE and SOTER databases. However, bulk density data are critical for a wide range of analyses, e.g. to compute soil nutrient content or soil water content on a volumetric basis. In the context of the present study, which is based on the 1:1 M and 1:5 M SOTER data, it has become necessary to develop simple PTFs for the estimation of bulk density where measured data are lacking.

Materials and methods

The general structure of the continuous PTF tested is:

$$Y = a.S + b.C + d.OC$$

in which:

Y = bulk density, the dependent variable (g cm^{-3})
S = silt content (wt %)
C = clay content (wt %)
OC = organic carbon content (wt %)
a, b and c are parameters

The basic data were derived from the WISE database. First, possible outliers were removed from the data set as follows:

- silt <2 % or >98%
- clay <2% or >98%
- organic carbon <0.2% or >30%
- bulk density <0.9 g cm^{-3} or >1.8 g cm^{-3} (to exclude Histosols, Andosols and very compact soils)

The range in measured characteristics for this data set (N=4326) is shown in table 4.

Table 4. Range in silt, clay, organic carbon and bulk density in data set.

	Silt	clay	orgC	bulk density
mean	31.6	34.3	1.12	1.40
st. dev.	18.4	20.1	1.4	0.22
covariance	58.4	58.3	119.65	15.44
minimum	2.00	2.0	0.20	0.90
1st quartile	16.0	18.0	0.38	1.25
median	29.0	32.0	0.66	1.42
3rd quartile	44.0	48.0	1.34	1.56
maximum	90.0	96.0	25.00	1.80

Results

First, a best subset regression was made for bulk density, giving the 3 "best" models from each subset size listed. Table 6 shows that the regressions that consider either silt and clay *or* silt, clay and organic carbon gave the highest coefficients of determination (r^2) for the considered data set (P<0.001). Based on this finding, full regression functions were then determined for these two combinations of dependent variables.

Table 5. Best subset regression for bulk density (N= 4326)

P	CP	r^2 adj.	r^2	resid. ss	model variables
1	3637.4	0.7229	0.7230	2411.57	A (silt)
1	3800.9	0.7173	0.7173	2461.08	B (clay)
1	14386.1	0.3489	0.3490	5667.43	C (org. C)
2	49.3	**0.8478**	0.8479	1324.10	A B
2	2968.0	0.7462	0.7464	2208.21	B C
2	3292.1	0.7350	0.7351	2306.38	A C
3	0.3	**0.8495**	0.8496	1309.47	A B C

The unweighed least squares linear regression of bulk density against silt, clay and organic carbon content is shown in table 6, giving an adjusted r^2 of 0.850 (P<0.0001), with a standard error of the estimate of 0.55 and a residual mean square of 0.30.

Table 6. Linear regression of bulk density against measured silt, clay and organic carbon content.

predictor variables	coefficient	std. error	student's T	P
silt	0.01870	3.433E-04	54.47	0.0000
clay	0.01723	3.003E-04	57.37	0.0000
org. C	0.04204	0.00605	6.95	0.0000

The unweighed least squares linear regression of bulk density against silt and clay content is shown in table 7, giving an adjusted r^2 of 0.848 (P<0.0001), with a standard error of the estimate of 0.55 and a residual mean square of 0.31.

Table 7. Linear regression of bulk density against measured silt and clay content.

predictor variables	coefficient	std. error	student's T	P
silt	0.01957	3.212E-04	60.93	0.0000
clay	0.01764	2.960E-04	59.59	0.0000

Conclusion

In conclusion, it can be observed that the PTFs in tables 6 and 7 can be used to fill-in missing data in (derived) data bases which contain measured data on particle size analysis and organic carbon, keeping in mind the still large scatter (figure 1). Consideration of organic carbon in the model as a dependent variable did not markedly influence the model's predictive capability.

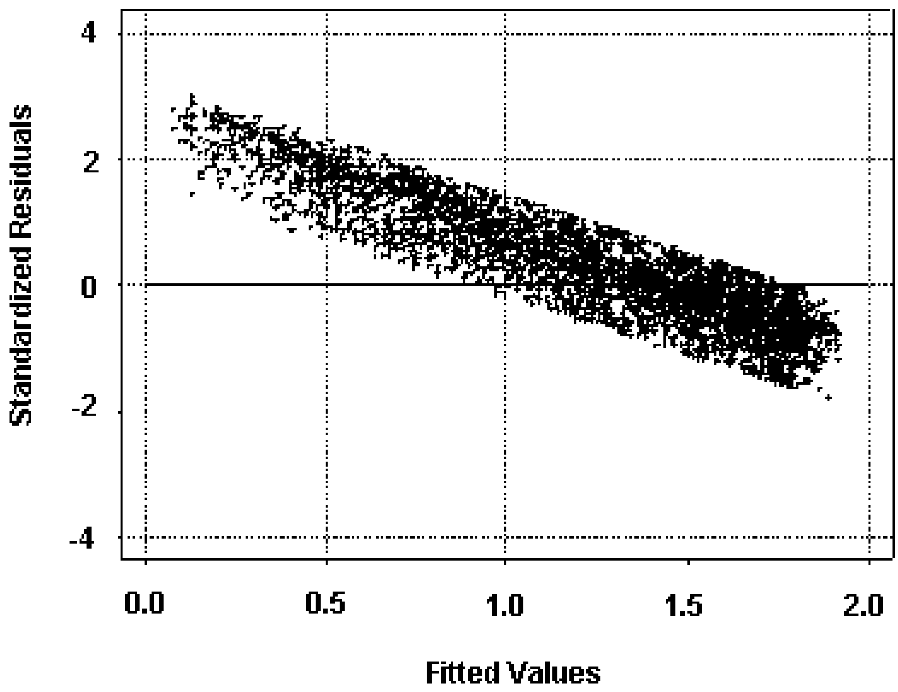


Figure1. Regression residual plot for bulk density as a function of clay and silt content.