



Application of remote sensing for schistosomiasis risk profiling

AK Fernerkundung, 25 September 2015 in Bonn

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Remote sensing of diseases

- > 80% of listed diseases have environmental risk factors; ca. ¼ of all fatalities (WORLD HEALTH ORGANIZATION, 2006)
- **Environmental factors**
characterise and localise the habitat of disease-causing or transmitting species
→ Impact on disease transmission



Schistosomiasis



- Parasitic worm disease
- High disease burden: End-organ pathologies, impaired growth and development of children, chronic inflammation, anaemia (HOTEZ AND FENWICK, 2009)
- 440 Millionen infected
 - 97% in Afrika (COLLEY ET AL., 2014)
 - 5% receive treatment (HOTEZ AND FENWICK, 2009)

Source: NTD Modelling Consortium
 (<http://www.ntdmodelling.org/diseases/schistosomiasis-japonica>)

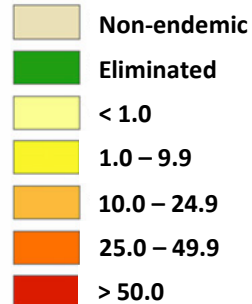
<http://everyday21000childrendie.wordpress.com/2012/01/12/schistosomiasis/>

“Disease burden of schistosomiasis in Africa equivalent to malaria or HIV/AIDS”

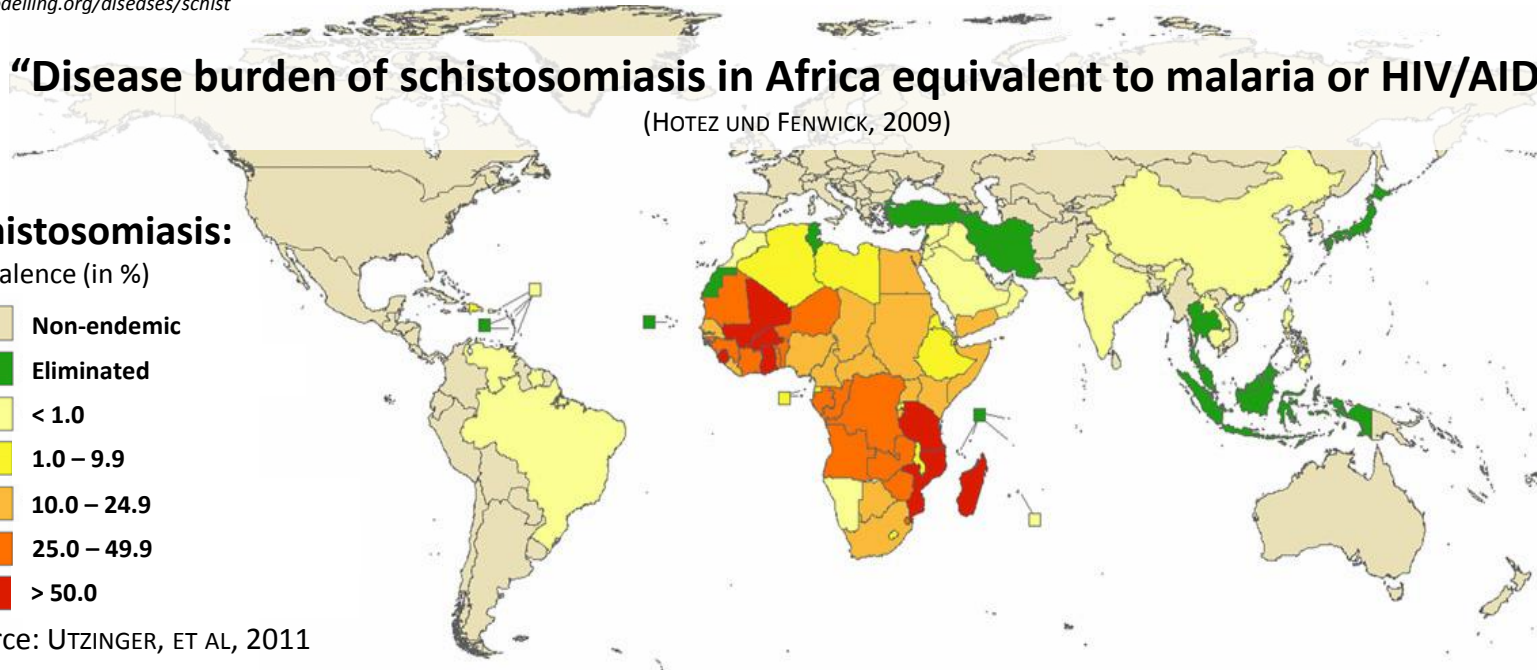
(HOTEZ UND FENWICK, 2009)

Schistosomiasis:

Prevalence (in %)



Source: UTZINGER, ET AL, 2011



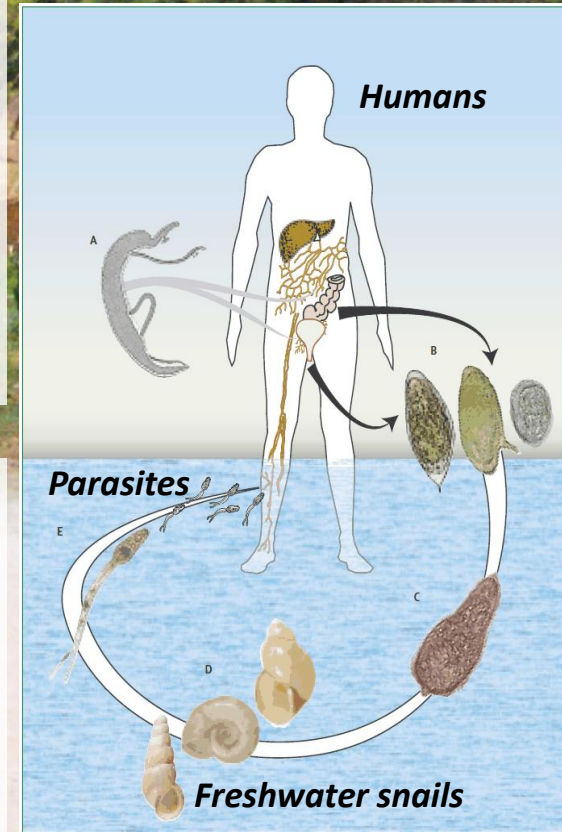
Transmission of schistosomiasis

Impact factors of humans:

- Behaviour / water contact
- Hygiene
- Immunity
- Cultural background
- Socio-economic status
- Migration
- Intervention measures
- Geolocation of household
- *etc.*

Impact factors of parasites & snails:

- Water temperature
- Flow velocity
- Stability of water level
- Water depth
- Vegetation
- Natural predators
- *etc.*



Source: COLLEY ET AL., 2014

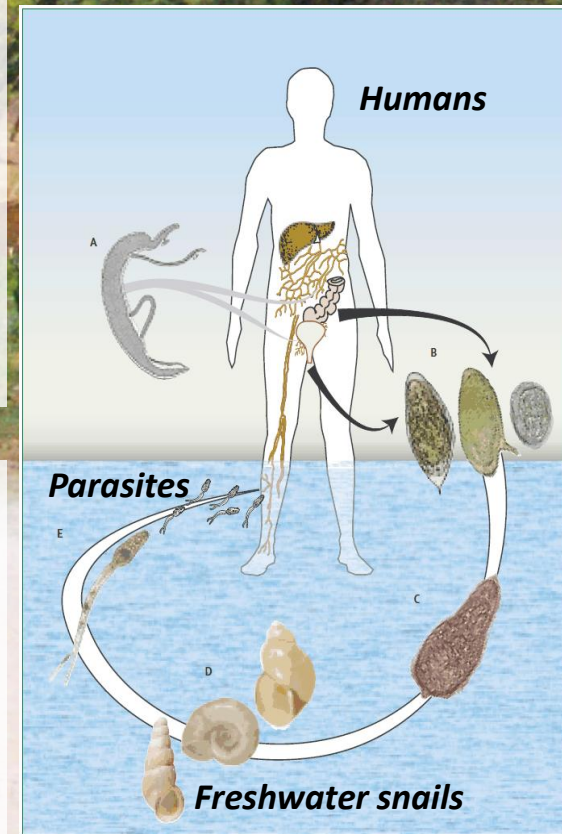
Transmission of schistosomiasis

Impact factors of humans:

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- *etc.*

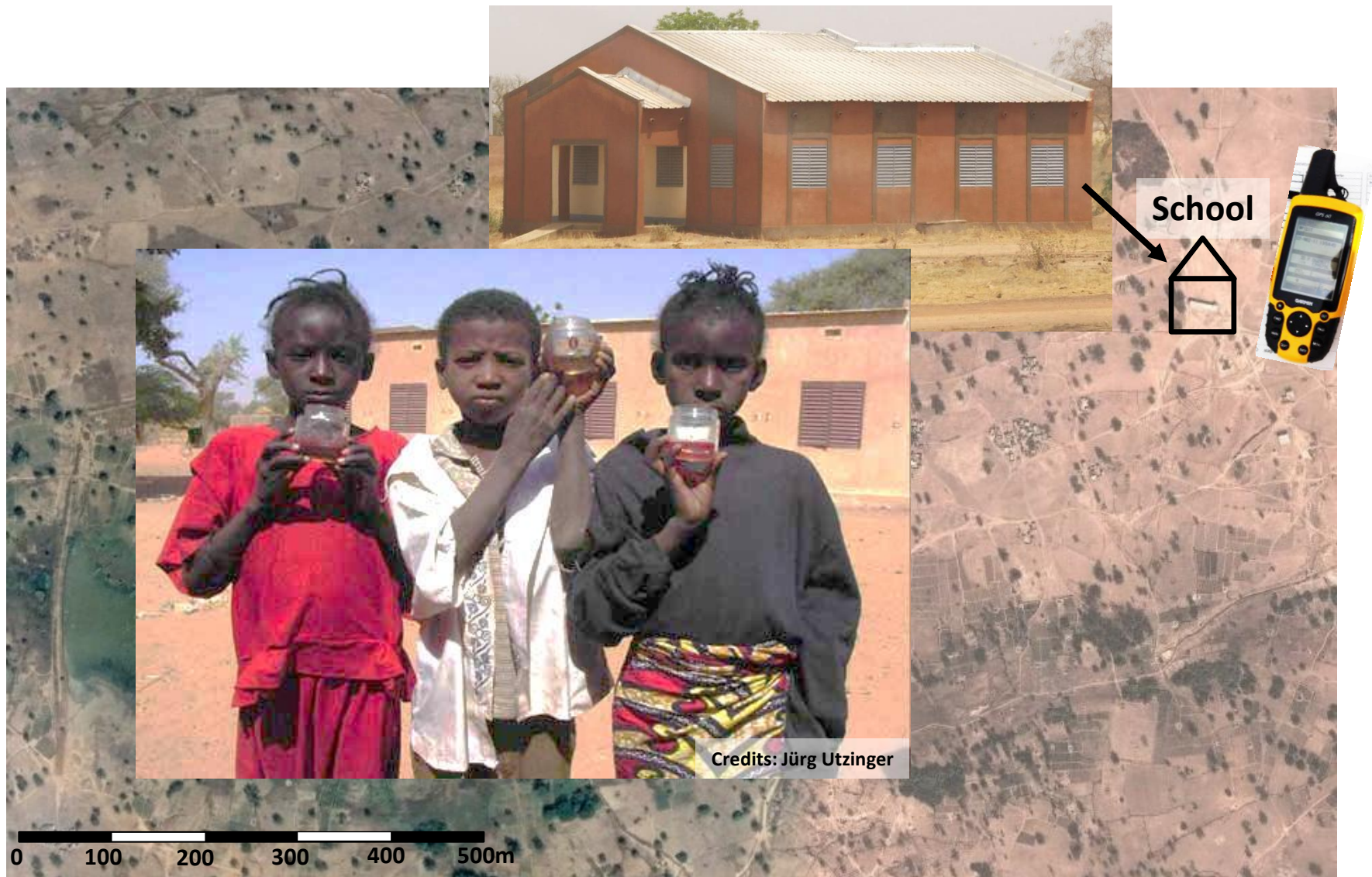
Impact factors of parasites & snails:

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- *etc.*



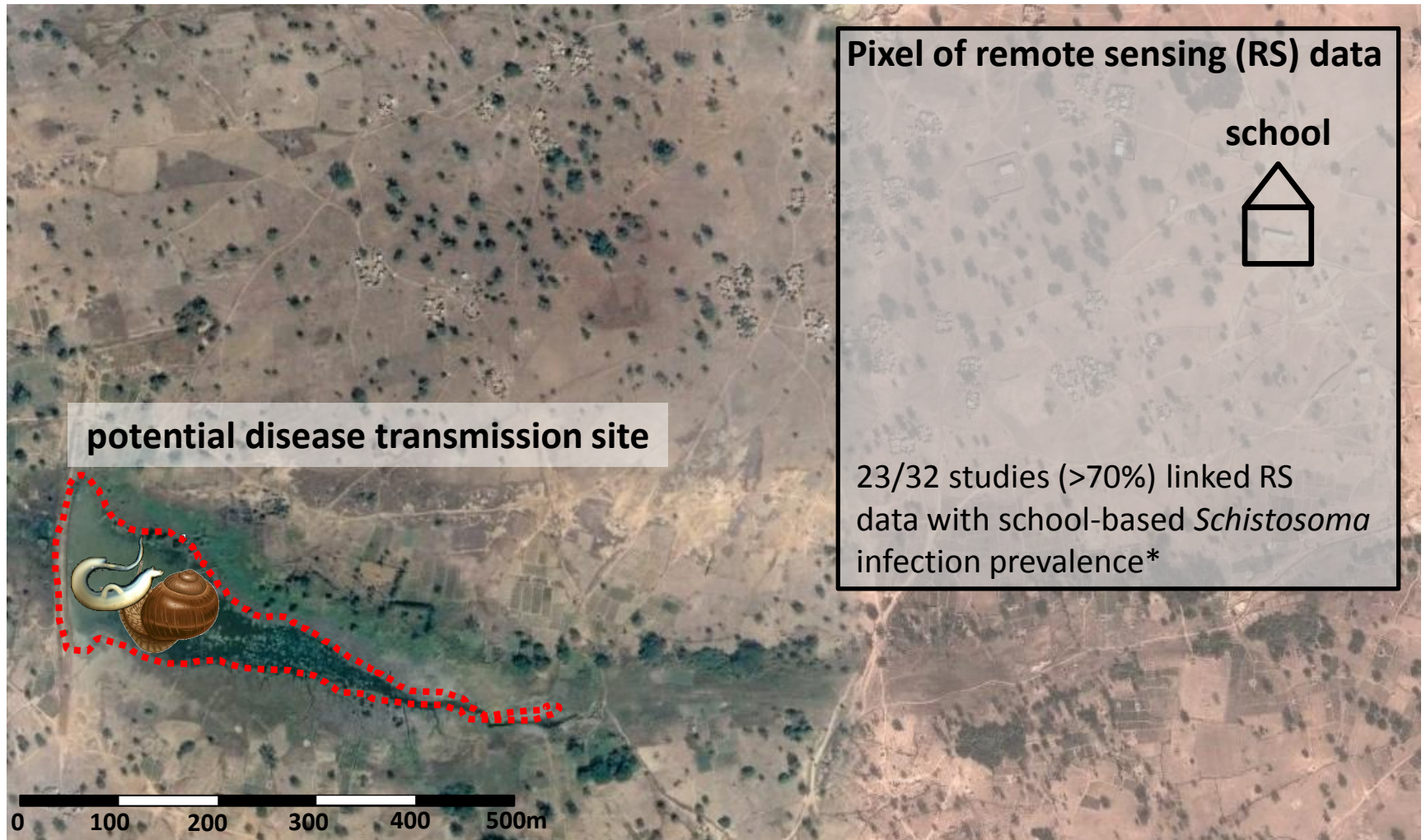
Source: COLLEY ET AL., 2014

Geolocation of data for risk modelling



Source: Google Earth (Image © DigitalGlobe 2011)

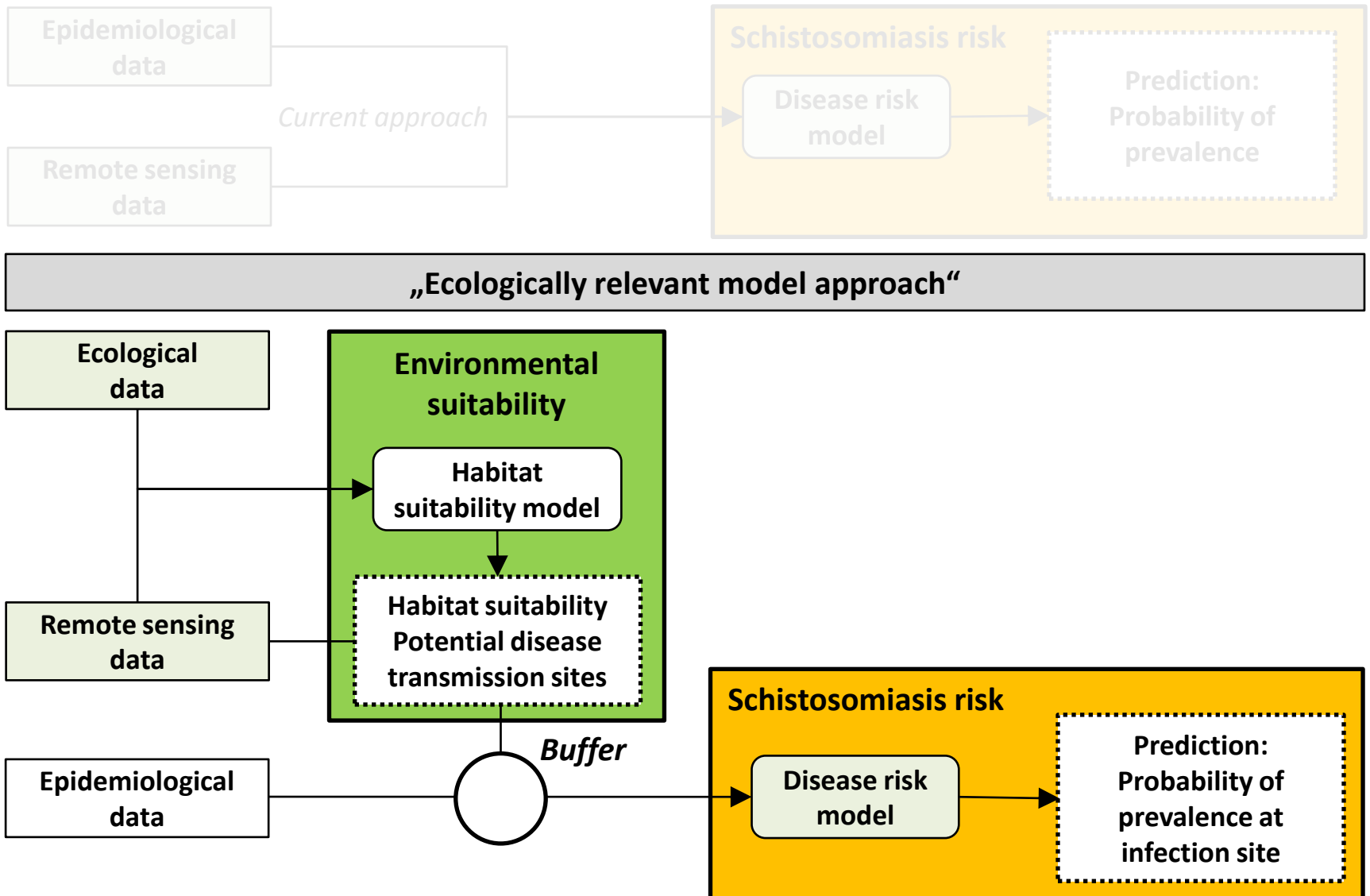
Geolocation of data for risk modelling



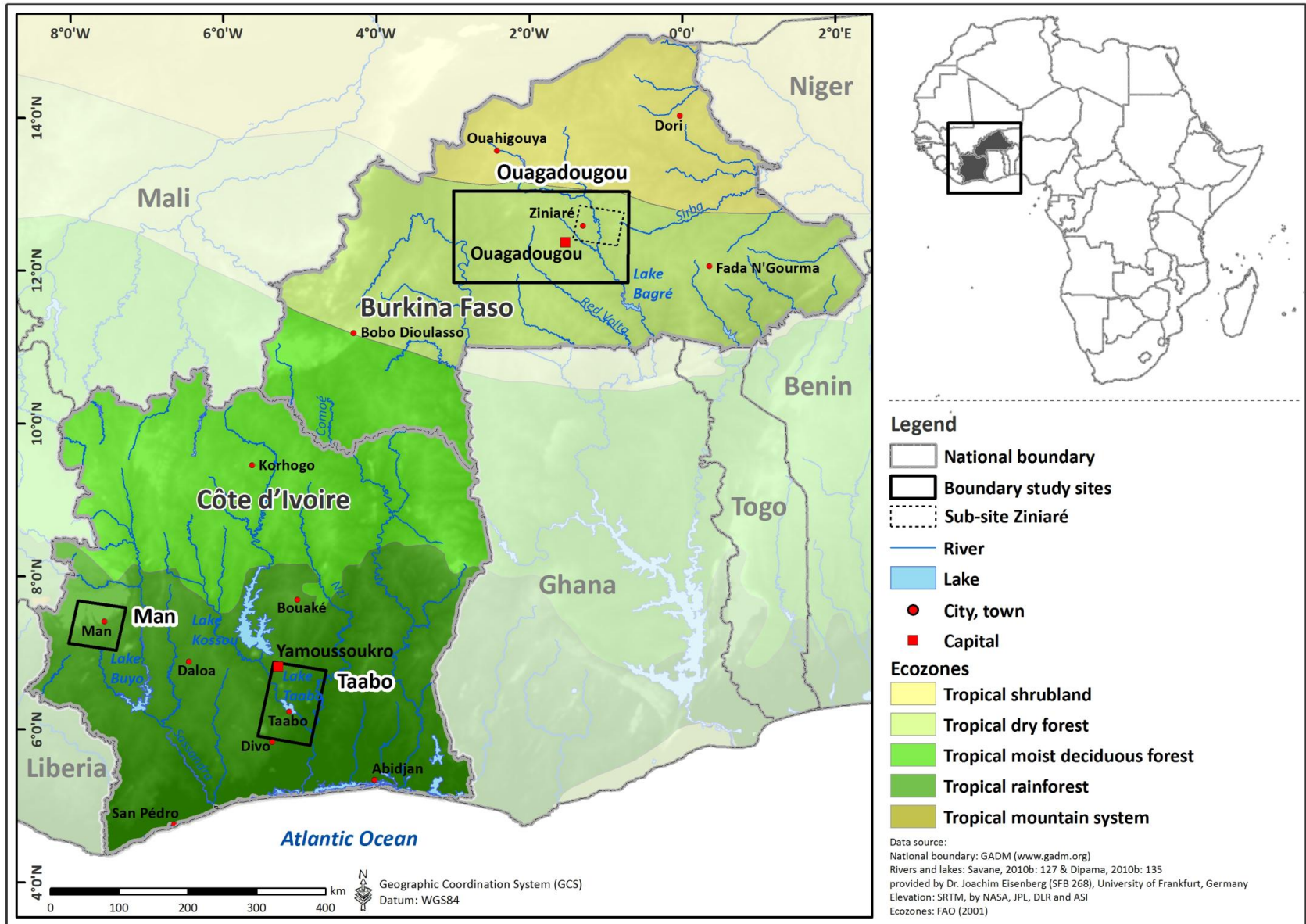
Source: Google Earth (Image © DigitalGlobe 2011)

*Walz, Y., Wegmann, M., Dech, S. Raso, G. and Utzinger, J. (2015). Risk profiling of schistosomiasis using remote sensing: approaches, challenges and outlook, *Parasites & Vectors* 8:163

Approach of spatial risk profiling

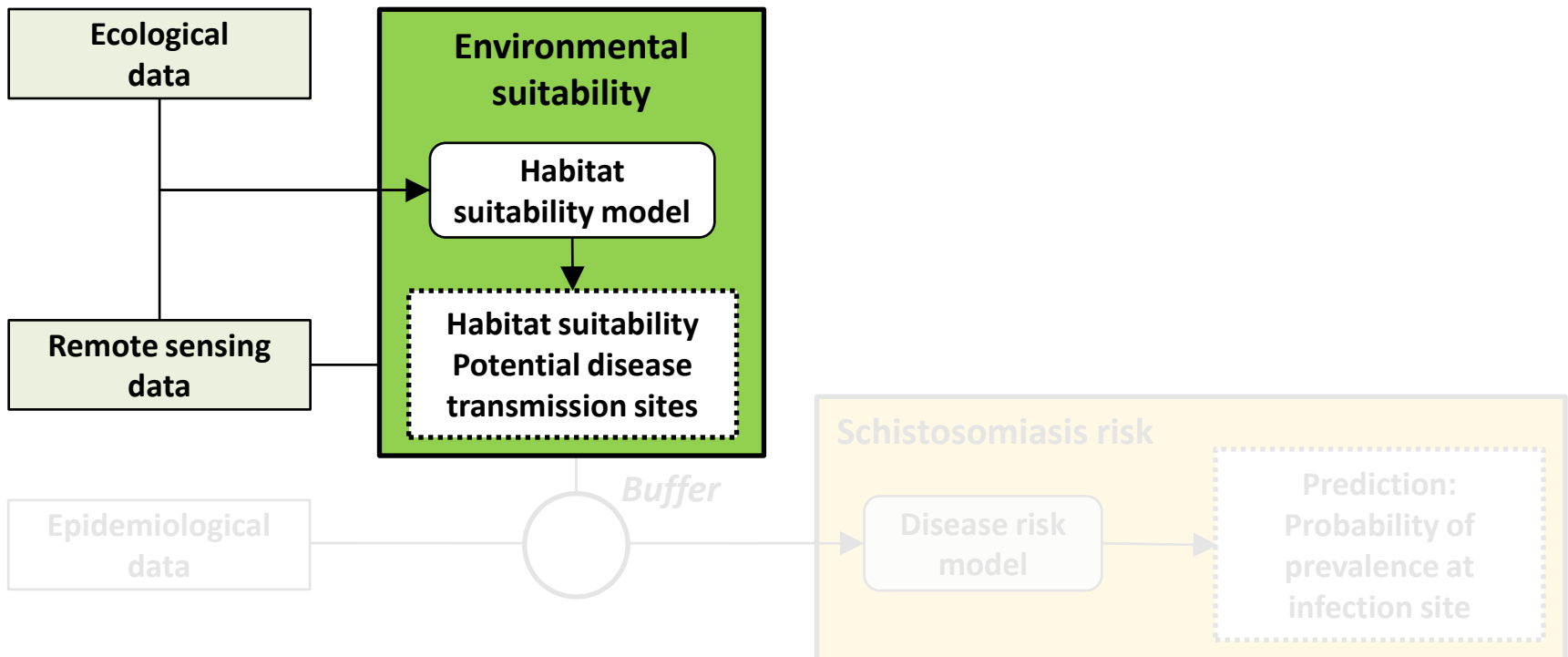


Study sites



Ecologically relevant model approach

Step 1: Derivation of potential disease transmission sites



Potential disease transmission sites

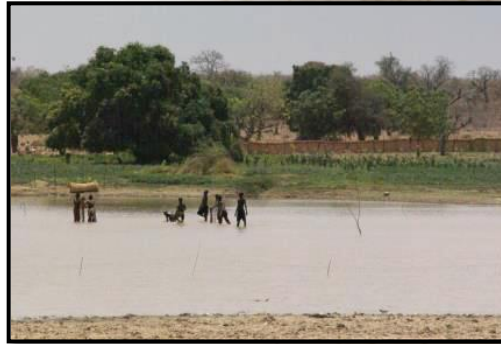
Irrigation channel



Irrigated ricefield



(Dam-) lake



Topographic sink



River

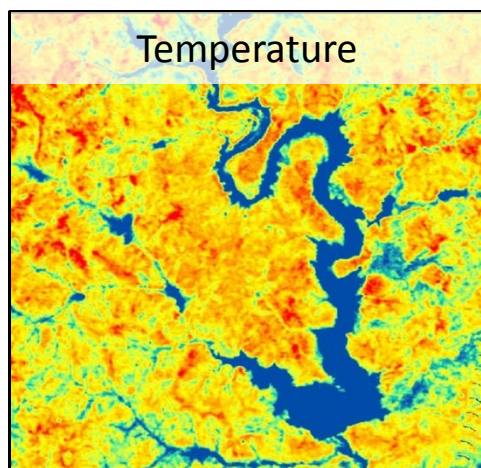


Seasonal water

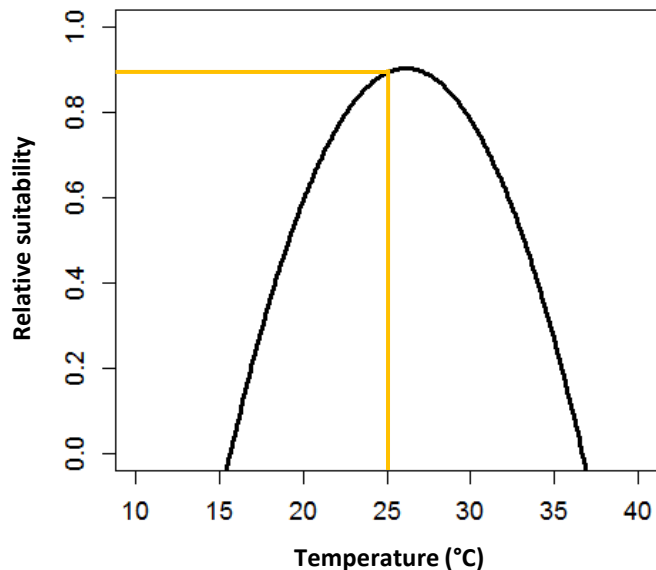


Habitat suitability model

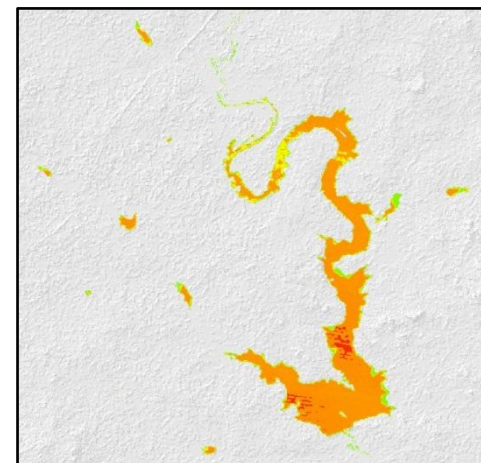
RS variables



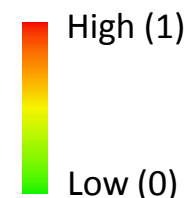
Ecological context



Relative habitat suitability:
Water temperature



Relative suitability

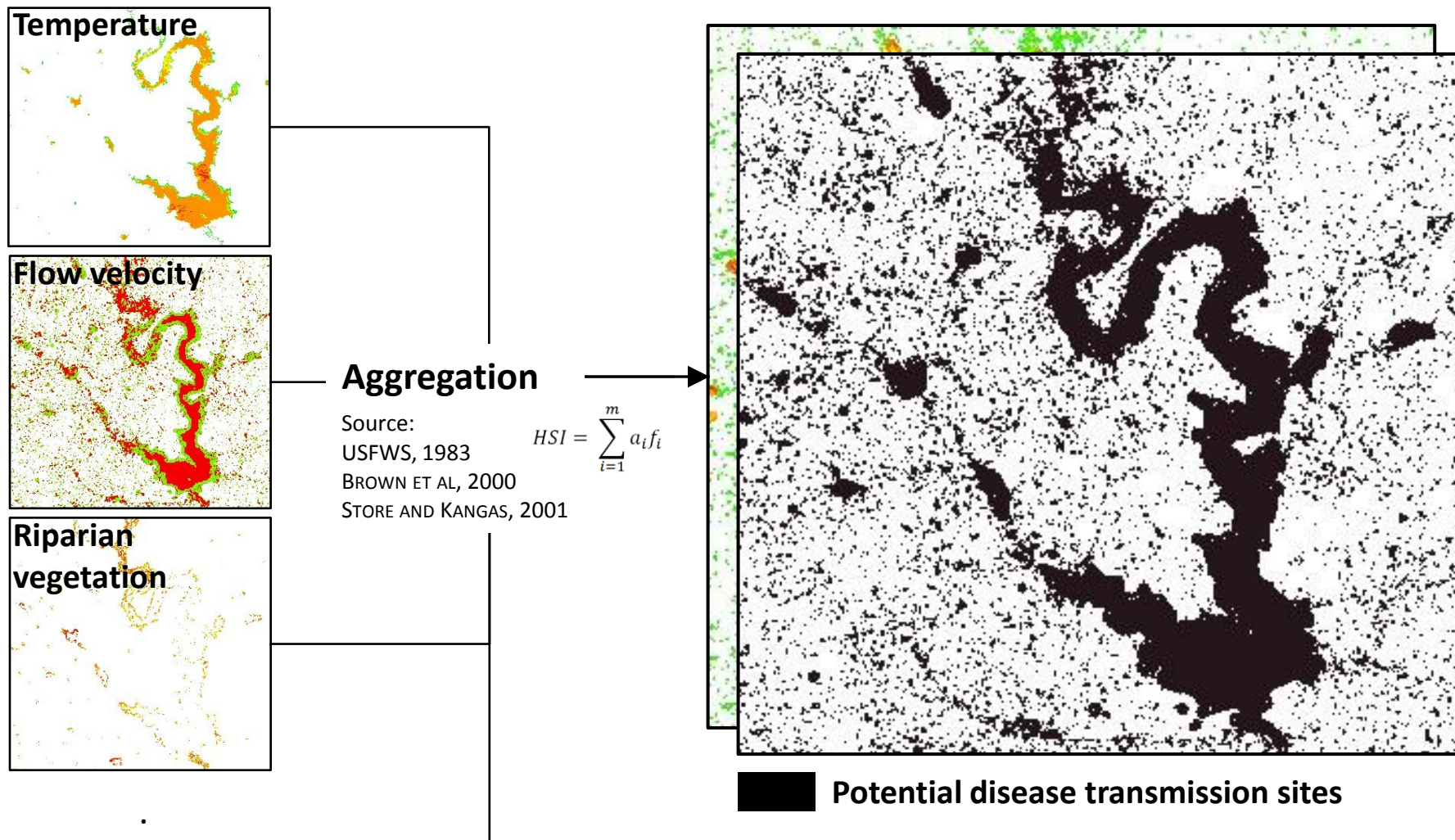


I. V. Scozza et al.: Stream Velocity as a Gradient in *Austrotrichia glabratus* 191
 Bull. Org. mond. Santé | 1958, 18, 785-818
Experimental Epidemiology of Schistosomiasis
 I. The Prepatent Period and Cercarial Production of *Schistosoma mansoni* in *Biomphalaria* Snails at Various Constant Temperatures
 W. Pfüger
 Institut für Medizinische Parasitologie der Universität Bonn,
 Sigmund-Freud-Str. 25, D-5300 Bonn 1, Federal Republic of Germany

Abstract. Laboratory experiments have permitted the quantification of the developmental times (prepatent periods) of *Schistosoma mansoni* in the snail over the whole possible range of constant temperatures. The basis relationship is satisfactorily described by a hyperbola of the formula $y = 268/(x - 14.2)$, y being the minimum time from miracidial infection to cercariae shedding (in days) x the mean temperature, and 14.2 the theoretical temperature threshold (in °C). Cercariae production takes place within the limits of +16° C and 35° C, the number of cercariae being low and the mortality of snails high at the extreme values. Long-term alternations between two temperature levels resulted in prepatent periods corresponding exactly to the proportional time-temperature products. However, slight accelerations of up to 7% and more could be

Habitat suitability / potential disease transmission sites

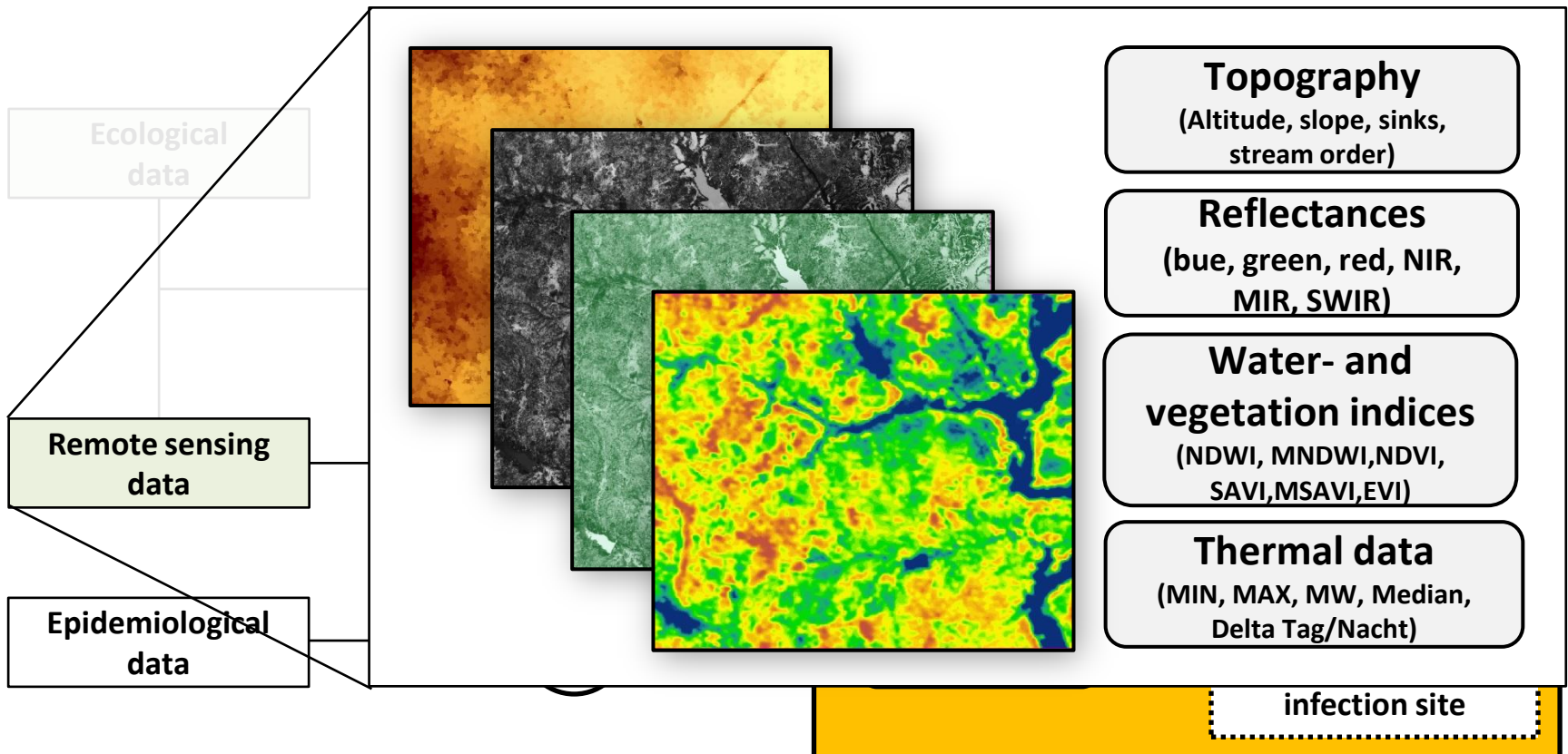
Relative habitat suitability



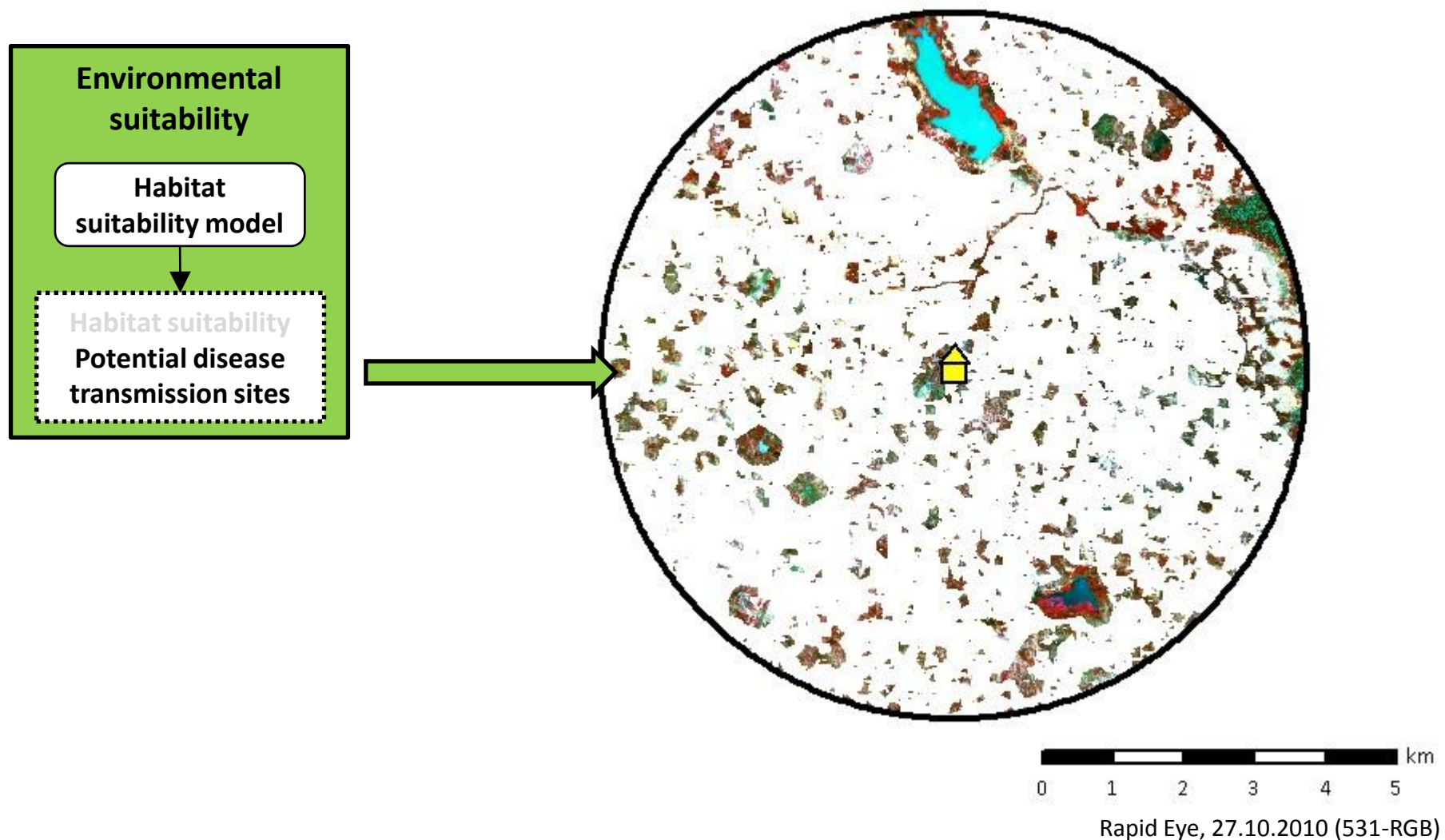
Ecologically relevant model approach

Step 1: Derivation of potential disease transmission sites

Step 2: Modelling of the infected population in reference to potential disease transmission sites

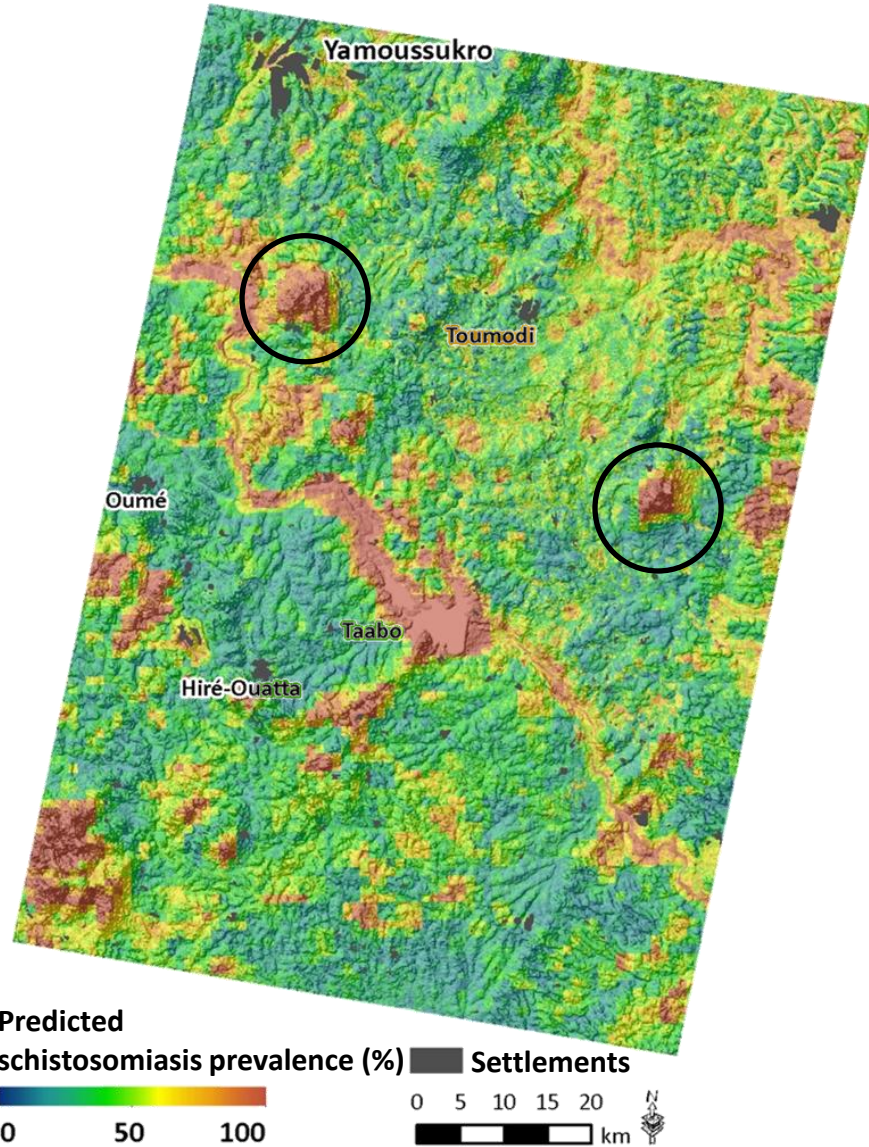


Ecologically relevant model approach

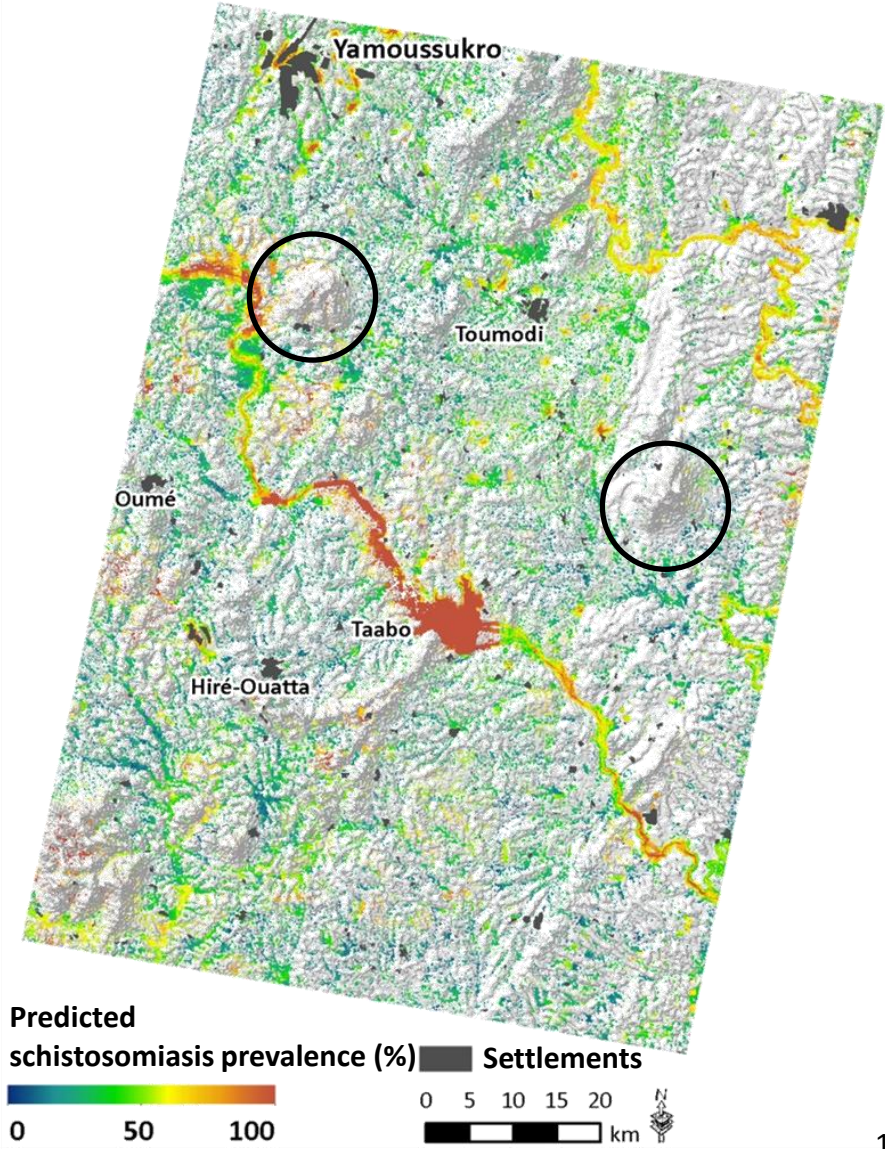


Spatial risk prediction

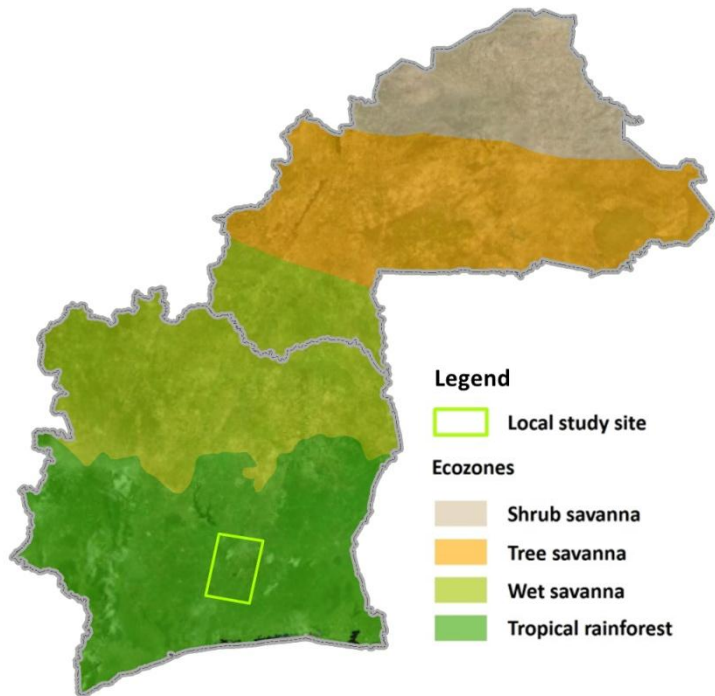
Full catchment model approach



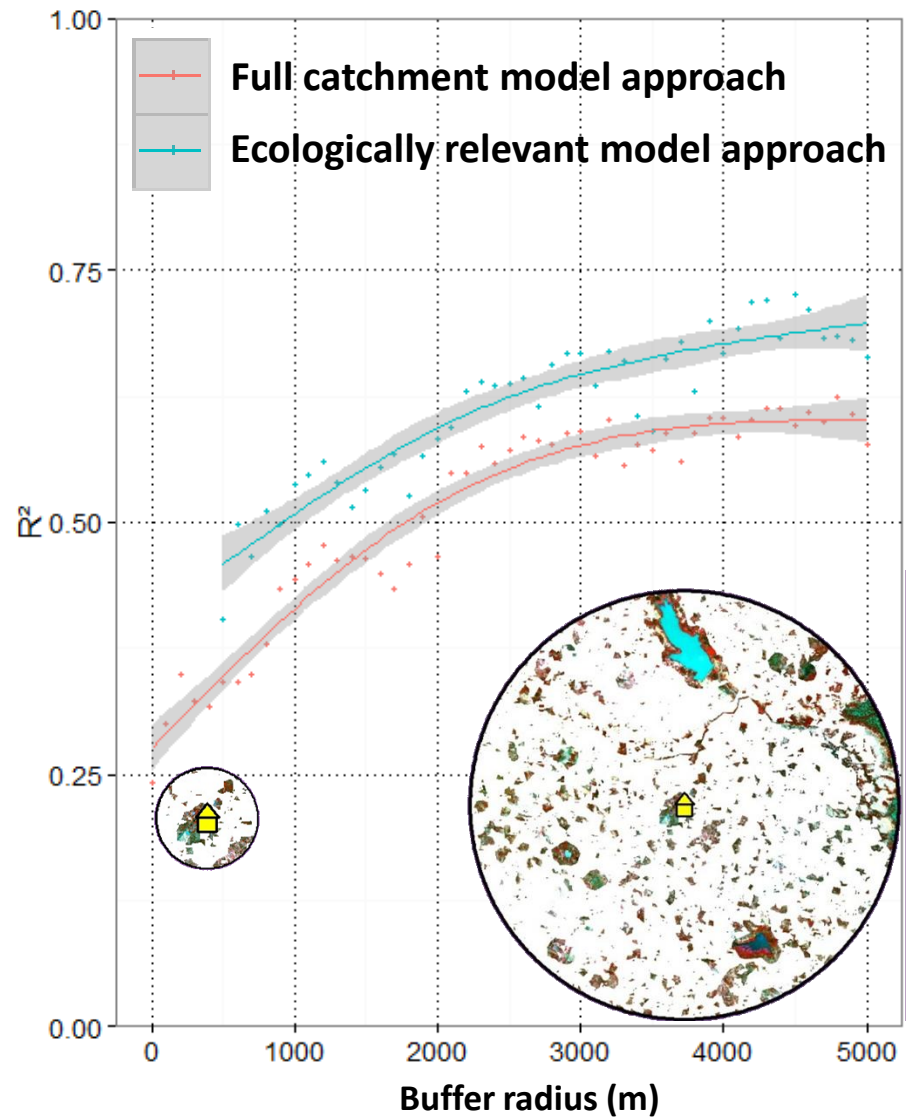
Ecologically relevant model approach



Model accuracy per buffer size



PLSR Modell
n=38
5-fold cross validation



Conclusion

- Concept of schistosomiasis risk modelling using remote sensing data requires consideration of the ecological and spatial context
→ Ecologically relevant model approach
- Model accuracy varies strongly with extent (=buffer size) of the catchment area considered for modelling schistosomiasis risk
- Multi-disciplinary approach essential for distilling causal relations





Thank you!



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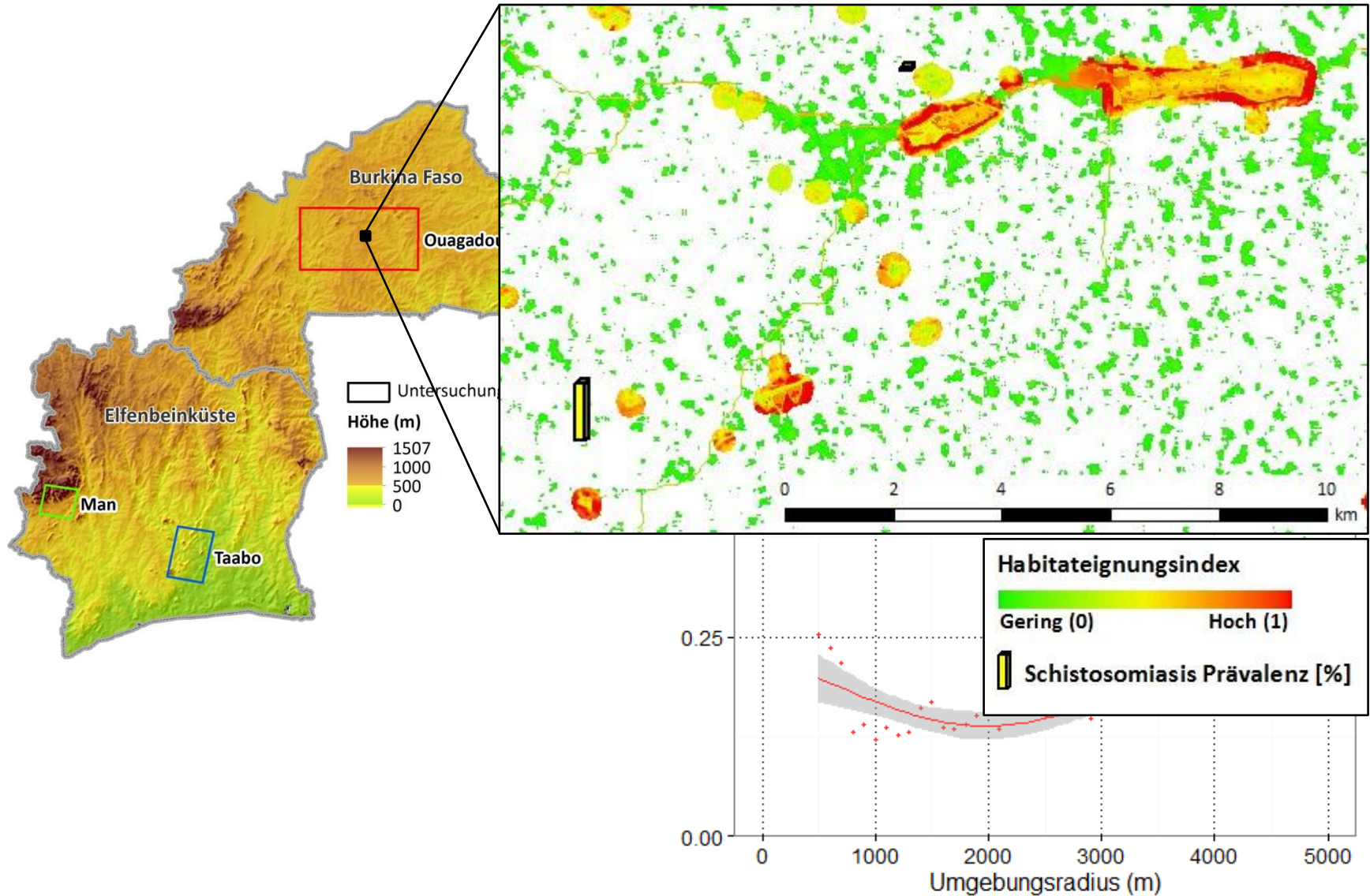
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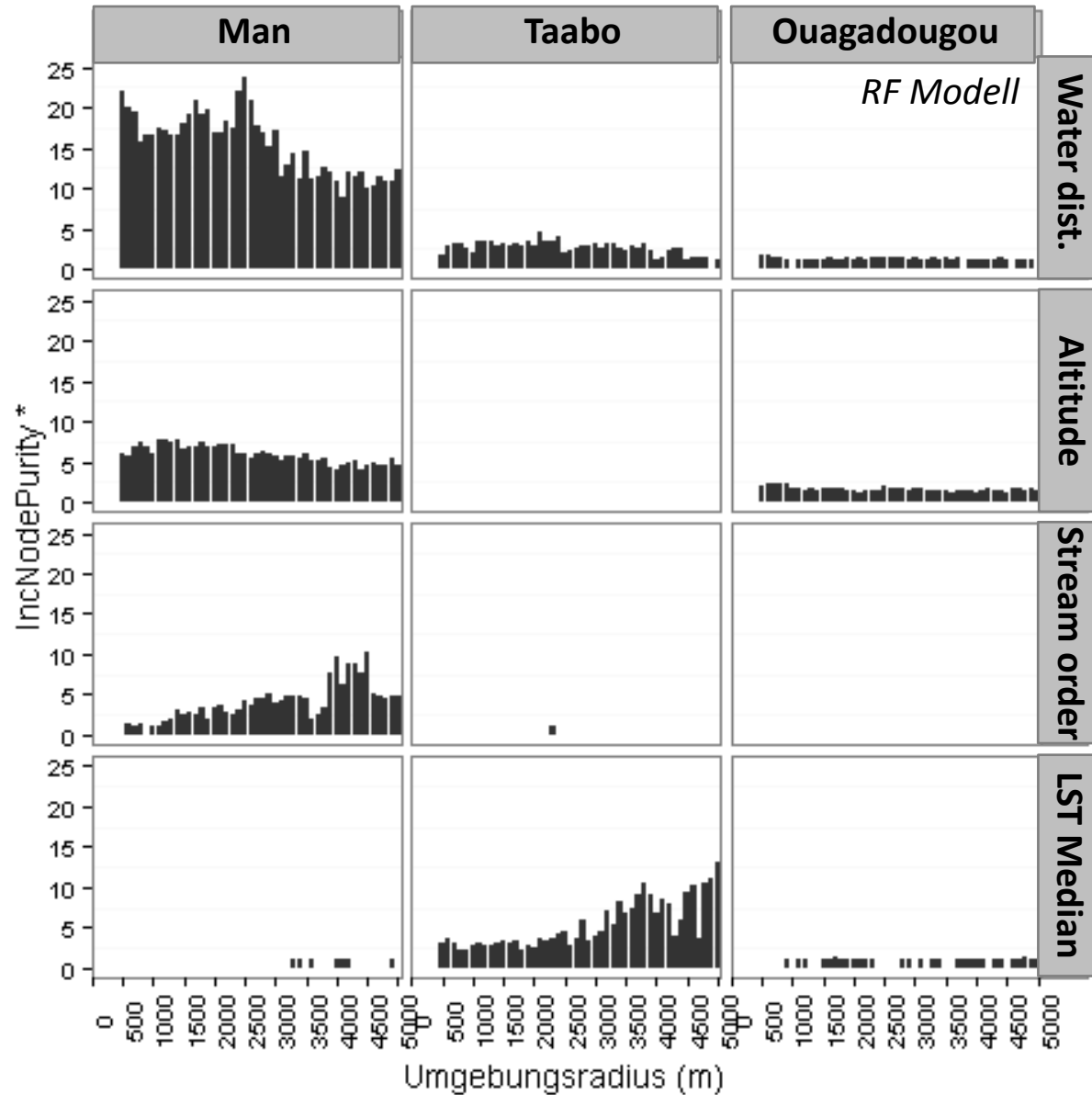
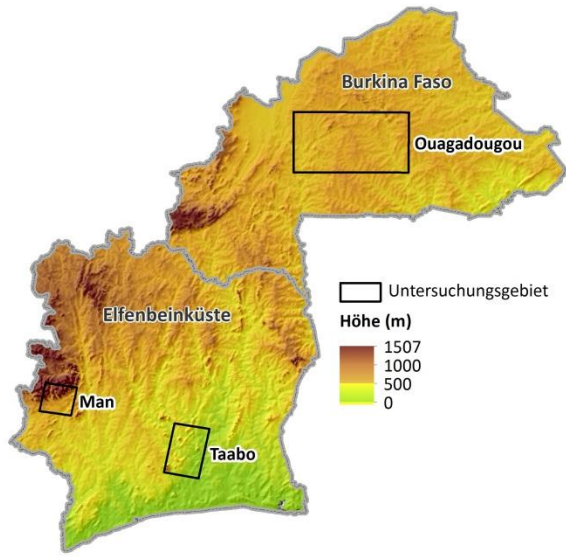
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Comparison between different study sites



Variable importance

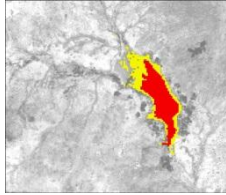


* Mean reduction of mean squared error (MSE)
BREIMAN (2001)

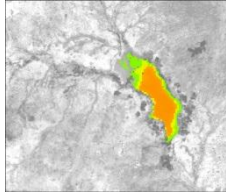
Habitat suitability model

Water suitability

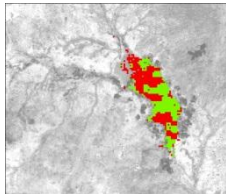
Habitat stability



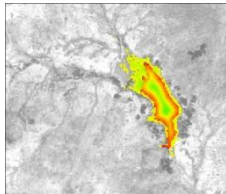
Temperature suitability



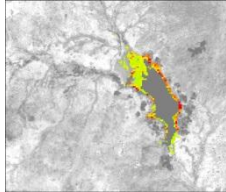
Flow suitability



Water depth suitability



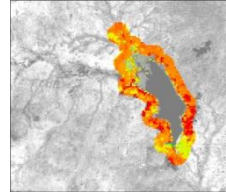
Dry season vegetation suitability



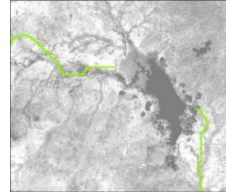
HSI_{water}

Potential water suitability

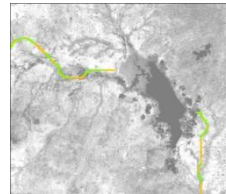
Vegetation suitability



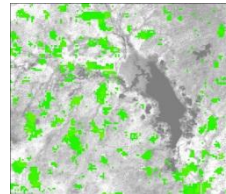
Stream suitability



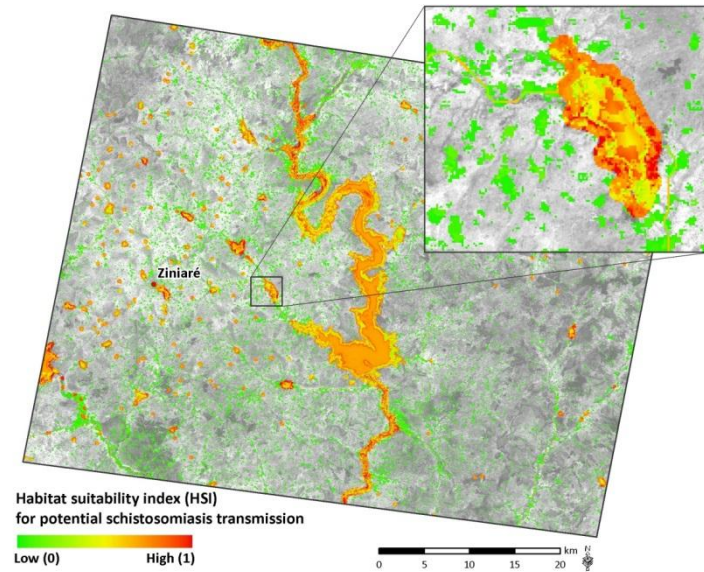
Potential flow suitability



Sink depth suitability



$HSI_{pot. water}$










Habitat suitability index (HSI)
for potential schistosomiasis transmission

Low (0) High (1)

0 5 10 15 20 km

Plausibility analysis: habitat suitability

	HSI	Reference: Estimated habitat suitability		HSI	Reference
Permanenter Stausee  Permanenter Fluss	0.6	High	Reisfeld 	0.97	High
 Stausee	0.55	Moderate	Bewässerte Landwirtschaft 	0.64	Moderate
	0.32	Moderate	Trockenes Flussbett 	0.55	Low
			Topographische Senke 	0.08	Low