Published in final edited form as:
Am J Trop Med Hyg. 2005 June ; 72(6): 655–657.

LETTERS TO THE EDITOR REMOTE SENSING OF MALARIA IN URBAN AREAS: TWO SCALES, TWO PROBLEMS

Simon I. Hay, PhD and **Andrew J. Tatem, PhD**
Department of Zoology, Tinbergen Building, University of Oxford, South Parks Road, Oxford OX1 3PS, United Kingdom and Centre for Geographic Medicine KEMRI, P.O. Box 43640, 00100 Nairobi GPO, Kenya

Dear Sir:

Two articles published in a supplement of the *American Journal of Tropical Medicine and Hygiene* make assertions about the use of remote sensing (RS) in urban areas that warrant further discussion. One evaluates qualitatively the impact of an eight-year investment of US $17 million by the Japanese International Corporation Agency (JICA) to control urban malaria in Dar es Salaam,[1] and the other investigates the impact of urbanization on malaria in sub-Saharan Africa and the implications of this for control.[2]

The first article states, after a limited investigation of aerial photography, that only optical imagery of 1 × 1 meter or finer spatial resolution is of use in delineating water-bodies for mapping malaria risk in urban areas,[1] a point further emphasized in an accompanying article.[3] The investigators then discuss the feasibility of the existing optical sensors in providing this information against issues of cost and opportunities for cloud free observation at tropical latitudes. There is a significant history of discussing these issues[4-9] that cite many examples of the cost-effectiveness of using aerial photography for mosquito larval habitat identification during control operations. Two further points should be made. The first is that exclusive use of optical sensors is not ideal for water-body discrimination, particularly in the cloudy tropics. Synthetic aperture radar (SAR) sensors are independent of solar radiation and thus can capture images at night and through complete cloud cover.[7] They have the further advantages of significant interaction of microwaves with water[10] and lower cost (e.g., complete coverage of Kenya at 25 × 25 meter spatial resolution with Radarsat US $5000 [Radarsat International http://www.rsi.ca/]). Furthermore, SAR imagery will soon be available at 1 × 1 meter spatial resolution from a variety of sources (e.g., http://www.terrasar.de/ and http://alos.nasda.go.jp). The second clarification is that not all remote sensing of urban areas[11-13] is focused explicitly on improving the ability of operational staff to identify larval habitats for larvicidal applications. Many studies have found that coarser resolution sensor information is also useful for identifying mosquito habitats.[12]

The second article attempts to estimate malaria incidence in African urban areas using an approach of dubious accuracy.[2] In the calculation of the land area that is urban in Africa, the investigators use night-time lights' imagery[14] developed by the Defense Meteorological Satellite Program for the National Oceanic and Atmospheric Administration. The use of these data in demographic applications has a substantial pedigree in RS. In night-time lights imagery, however, considerable contamination of dark pixels can occur from adjacent bright pixels (a phenomenon known as blooming) and adjustments need to be made. The RS

Telephone: 44-1865-271-243, Fax: 44-1865-271-243, simon.hay@zoo.ox.ac.uk and andy.tatem@zoo.ox.ac.uk.

specialist must therefore balance the likely underestimate of urban centers because some of these lack bright lights (factors between two and three are applied to allow for this effect) and the certain overestimate of other urban areas through blooming effects.[14-18] When only the first factor is considered, between 1.7% and 2.6% of Africa is estimated to be urban[2]; this is likely to be an overestimate because of the second effect. In a recent analysis of settlement patterns in Kenya,[18] a number of estimates of urban areas were tested. Those incorporating night-time lights imagery predicted significantly larger urban areas than those using visual interpretation of satellite imagery (http://www/africover.org). The most recently available Global Urban Rural Mapping Project[19,20] reported that only 0.8% of the surface of Africa is urban. Extrapolating these values to malaria incidence using only eight studies, and thereby claiming 6–28% of the global malaria incidence may occur in African urban areas,[2,3] should therefore be treated with caution because it is almost certainly an overestimate of unknown magnitude.

Acknowledgments

Simon I. Hay is supported by a Research Career Development Fellowship from the Wellcome Trust (#069045).

REFERENCES

1. Caldas de Castro M, Yamagata Y, Mtasiwa D, Tanner M, Utzinger J, Keiser J, Singer BH. Integrated urban malaria control: a case study in Dar es Salaam, Tanzania. Am J Trop Med Hyg. 2004; 71(2 Suppl):103–117. [PubMed: 15331826]
2. Keiser J, Utzinger J, Caldas de Castro M, Smith TA, Tanner M, Singer BH. Urbanization in sub-Saharan Africa and implication for malaria control. Am J Trop Med Hyg. 2004; 71(2 Suppl):118–127. [PubMed: 15331827]
3. Breman JG, Alilio MS, Mills A. Conquering the intolerable burden of malaria: what's new, what's needed: a summary. Am J Trop Med Hyg. 2004; 71(2 Suppl):1–15. [PubMed: 15331814]
4. Hay SI, Packer MJ, Rogers DJ. The impact of remote sensing on the study and control of invertebrate intermediate host and vectors for disease. Int J Remote Sens. 1997; 18:2899–2930.
5. Hay SI, Tucker CJ, Rogers DJ, Packer MJ. Remotely sensed surrogates of meteorological data for the study of the distribution and abundance of arthropod vectors of disease. Ann Trop Med Parasitol. 1996; 90:1–19. [PubMed: 8729623]
6. Hay SI, Snow RW, Rogers DJ. From predicting mosquito habitat to malaria seasons using remotely sensed data: practice, problems and perspectives. Parasitol Today. 1998; 14:306–313. [PubMed: 17040796]
7. Hay SI. An overview of remote sensing and geodesy for epidemiology and public health application. Adv Parasitol. 2000; 47:1–35. [PubMed: 10997203]
8. Rogers DJ, Randolph SE, Snow RW, Hay SI. Satellite imagery in the study and forecast of malaria. Nature. 2002; 415:710–715. [PubMed: 11832960]
9. Hay SI, Omumbo JA, Craig MH, Snow RW. Earth observation, geographic information systems and *Plasmodium falciparum* malaria in sub-Saharan Africa. Adv Parasitol. 2000; 47:173–215. [PubMed: 10997207]
10. deLoor GP. The dielectric properties of wet materials. IEEE Trans Geosci Remote Sens. 1983; 21:364–369.
11. Tatem AJ, Noor AM, Hay SI. Defining approaches to settlement mapping for public health management in Kenya using medium spatial resolution satellite imagery. Remote Sens Environ. 2004; 93:42–52. [PubMed: 22581984]
12. Tatem AJ, Hay SI. Measuring urbanization pattern and extent for malaria research: a review of remote sensing approaches. J Urban Health. 2004; 81:363–376. [PubMed: 15273262]
13. Eisele TP, Keating J, Swalm C, Mbogo CM, Githeko AK, Regens JL, Githure JI, Andrews L, Beier JC. Linking field-based ecological data with remotely sensed data using a geographic information system in two malaria endemic urban areas of Kenya. Malaria J. 2003; 2:44.

14. Elvidge, C.; Hobson, VR.; Nelson, IL.; Safran, JM.; Tuttle, BT.; Dietz, JB.; Baugh, K. Overview of DMSP OLS and scope of applications. In: Mesev, V., editor. Remotely Sensed Cities. Taylor and Francis; London: 2003. p. 281-299.
15. Schneider A, Friedl MA, McIver DK, Woodcock CE. Mapping urban areas by fusing multiple sources of coarse resolution remotely sensed data. Photogrammetric Eng Remote Sens. 2003; 69:1377–1386.
16. Sutton P, Roberts D, Elvidge C, Baugh K. Census from Heaven: an estimate of the global human population using night-time satellite imagery. Int J Remote Sens. 2001; 22:3061–3076.
17. Sutton P. A scale-adjusted measure of “urban sprawl” using nighttime satellite imagery. Remote Sens Environ. 2003; 86:353–369.
18. Tatem AJ, Noor AM, Hay SI. Accuracy of urban area delineation using remotely-sensed imagery in Kenya. Remote Sens Environ. 2005 in press.
19. Balk, D.; Yetman, G. The Global Distribution of Population: Evaluating the Gains in Resolution Refinement. Columbia University Center for International Earth Science Information Network; New York: 2004.
20. CIESIN/IPFRI/CIAT. Global Rural Urban Mapping Project (GRUMP): Gridded Population of the World, Version 3, with Urban Reallocation (GPW-UR). Columbia University Center for International Earth Science Information Network (CIESIN)/International Food Policy Research Institute (IPFRI)/The World Bank/Centro Internacional de Agricultura Tropical (CIAT); Palisades, NY: 2004.