Rapid urbanization and food security:
Using food density maps to identify future food security hotspots

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The cities of the developing world are spectacularly ill-prepared
for the explosion in urban living.
Hans van Ginkel (in *Nature*, 2008)

1 Introduction

Between 2007 and 2050 the world population is projected to increase from 6.7 to 9.2 billion, and most of this growth will occur in urban areas of less developed countries (United Nations 2008). Urbanization *per se* is often a positive development, as urban areas tend to be more productive than rural areas; and therefore a driver of economic growth and development (Overman and Venables 2005). Yet, rapid urbanization – as it is currently occurring in many developing countries – can outstretch the capacities of cities to absorb and cater for an ever growing number of inhabitants.

If unabsorbed, urbanization may lead to the development of slums and pose a considerable threat to all dimensions of food security, because the majority of urban dwellers are net food buyers and spent a large part of their disposable income on food. In particular the 2007/2008 food crisis demonstrated the vulnerability of the urban poor and the strong link between food and national security. When prices for staple food crops – like wheat, maize, and rice – started to rise at the end of 2007 and reached decade highs in early 2008, the urban poor were hit the hardest. This led to food-related riots and conflicts.

If cities do not adapt to their new realities, the expected boost in urbanization and population growth could further increase the vulnerability of urban dwellers to sudden shocks in agricultural markets. To avoid such kind of scenario, policy-makers will have to react to these risks by developing strategies that address urban food security. Given limited resources, such strategies have to be efficiently directed at future food security hotspots.

Food density maps can be one instrument in identifying such area. They combine current and projected per capita food availability with current and projected population densities. This is displayed in geo-referenced maps, which present food density in calories/km^2/day. Food density

maps consequently incorporate three main factors: i) population growth ii) growth in population densities and iii) growth in food consumption expressed in daily calories available per person per day (Schmidhuber and Müller 2008).

The objective of this paper is to outline the relationship between urbanization and food security and to compare food density maps for 2005 and 2050 in order to point out potential future food security hotspots, i.e. areas where the pressure on food delivery systems is projected to be particularly high. The paper proceeds as follows: Section 2 discusses the challenges of urbanization in developing countries and describes how urbanization may affect food security. Section 3 describes the development of food density maps and compares food density maps of Sub-Saharan Africa and South and East Asia in 2005 and 2050. Section 4 concludes.

2 The challenges of rapid urbanization in developing countries

2.1 Urbanization in developing countries

The share of urban to total world population increased from 29 percent in 1950 to 50 percent in 2008, and the lion share of this raise is attributed to developing countries. This rapid – and often uncontrolled – urbanization is unprecedented by historical standards (van Ginkel 2008). Yet, urbanization rates in developing regions differ widely: While in Latin America and the Caribbean urbanization rates stand at 78 percent, only 38 percent of the African population lives in urban areas. Urbanization rates are expected to increase to 70 percent in 2050; with Africa and Asia being projected as the regions that will experiences the largest growth in their urban populations (United Nations 2008). What is also without any historical parallel is the growth of so-called "megacities": From 1975 to 2007, the number of megacities with more than 10 million inhabitants increased more than six times from 3 to 19 cities worldwide (United Nations 2008).

Despite that record growth, the majority of urban dwellers (about 61%) live in small to medium-sized cities of up to one million inhabitants. This holds for developed and developing countries, and is not expected to change in the long-term. Yet, small to medium-sized cities, particularly in developing countries, often lack infrastructure and basic services – like water, sanitation, electricity, health care, and waste disposal – to absorb an ever increasing number of people (Cohen 2006; Montgomery 2008). This frequently leads to the development of city slums, which are defined as low-income, overcrowded settlements with poor human living conditions

(UN-HABITAT 2003). In fact, in 2005, 51 percent of Africa's urban population lived in slums; with as many as 86 and 94 percent in Angola and Sudan, respectively (United Nations 2007).

Uncontrolled urbanization and low absorption capacities by cities have a strong effect on poverty rates. A recent study by Chen and Ravallion (2007), which used time-series data of more than 200 countries from 1981 to 2004 to compare rural-urban poverty rates, found that poverty rates are becoming more and more urbanized. The authors established that, despite the fact that the majority of the poor continues to reside in rural areas, the incidence of urban poverty in comparison to total poverty incidence increased with urbanization. This essentially signifies that the poor urbanized faster and/or that urban poverty decreases slower in comparison to rural areas (Chen and Ravallion 2007).

Thus, why *do* cities grow? Contrary to popular belief, 60 percent of urban growth are due to natural growth (i.e. a higher birth than death rates), and 40 percent to rural-urban migration and area expansions (Montgomery 2008). Even though the share of migration in total urban growth is smaller than natural growth rates, the absolute number of people pouring into cities every year is enormous. Rural-urban migration is often caused by a mix of pull and push factors. *Pull factors* make cities attractive to rural migrants: Cities often offer higher wages and better employment options, particularly for women. In addition, cities tend to have a better and greater availability of services, like health care and education, than rural areas. Finally, cities are centers of modern living: They offer large varieties of cultural and social opportunities (Overman and Venables 2005; Cohen 2006). *Push factors*, on the other hand, force migrants to leave rural areas. Examples for push factors include displacement by conflict, disasters, or droughts; land degradation and desertification; population pressures in rural areas; and flight from discrimination and social stigma in rural areas (FAO 2008).

2.2 Urbanization and food security

The Food and Agriculture Organization of the United Nations (FAO) defines food security as a situation that "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). This definition comprises four dimensions of food security: availability, stability, safety, and access. The first dimension relates to the general availability of sufficient amounts of food. Food stability requires that food can be accessed at all times. Food safety is linked to the quality of food: It is not enough that sufficient amounts of food are available, if they it can not be consumed

without risking major health problems. The final dimension, access to food, is associated with the resources that an individual or household possesses to obtain food required for a healthy diet (Schmidhuber and Tubiello 2007). Urbanization affects all four dimensions of food security as discussed shortly below.

Food availability: In the future, agriculture will be challenged to meet the demand of a population that is projected to grow *and* to urbanize. This implies that more food will be demanded by a population of net food buyers; and food demand will have to be met by rural and peri-urban areas and/or by food imports. Yet, sprawling cities may put constraints on the ability to meet new demand patterns due to, among other factors, land-use changes associated with urbanization and increased competition for irrigation water.

As cities expand, prime agricultural land is converted into residential or industrial areas. For example, in Conception, a Chilean city of about 500,000 inhabitants, 1734 hectares of wetlands and 1417 hectare of agricultural land and forests were transformed into residential areas over the period 1975 to 2000 (Pauchard et al. 2006). In Accra (Ghana), it is estimated that 2600 hectares of agricultural land are converted every year (Maxwell et al. 2000). Similar patterns were observed in China and Indonesia (Verburg 1999; Weng 2002). An immediate consequence is the crowding out of peri-urban agriculture, which often plays a significant role in supplying perishable foodstuffs to cities. In addition, already weak tenure agreements may be challenged; and agricultural production may shift to less productive areas, which could, *ceteris paribus*, result in yield losses (FAO 2008). Land-use changes due to city expansions can also imply irreversible losses in biodiversity (Pauchard et al. 2006).

Agricultural production will be further challenged by the expanding cities' substantial thirst for water. For example, Showers (2002), in a review of water policies in 37 African countries, showed that in the 1970s most urban areas used to draw their water from groundwater source in or close to the city. Yet, with a raising demand in water for domestic and industrial purposes, caused by higher urbanization rates, countries have draw ground water and surface water from ever more far places. This puts pressure on distant ecosystems, and lowers water table, which may lead to increasingly dry zones in soils. As African agriculture is mainly rainfed, increased drought stresses will affect crop yields and thereby production. In addition degraded areas may also less able to absorb water and retain precipitation. This may in turn lead to a vicious circle in which the affected rural population is "pushed" to the urban areas, thereby putting more pressure on water demand (Showers

2002).

Food stability: Expansion also means that more and more food will have to be transported to and distributed within the cities. This will put additional pressure on rural infrastructures, transport technologies, and food distribution outlets. Since these tend to be already insufficient in urban areas of many developing countries, the stability of food supplies may be jeopardized (FAO 2008). Bayo (2006, pp. 116-117) vividly illustrated these challenges for Nigeria: "Without the urban and peri-urban contributions to a city's nutrient intake, the challenge of feeding the cities will be enormous. For a city of about four million inhabitants, food requirements average about 3000 tons a day. This implies about two three-ton trucks entering the city every three minutes. Staple food materials, vegetable, fruits, fish, meat (...) will originate from different areas. This will pose logistical challenges in view of transportation, city traffic, sheer quantity and variety needed, handling etc." For most cities these challenges would apply to domestically produced and imported food alike.

Food safety: Numerous studies found that urbanization generally decreases child malnutrition and increases dietary diversity (e.g. Ruel and Garrett 2004). However, in urban areas food is increasingly consumed outside the house. For example, in Tanzania it is estimated that 70% of the caloric requirements of low and middle income groups are met by street foods (FAO 2004). Maxwell et al. (2000), in a survey of 559 urban households in Accra (Ghana), found that more than 32 percent of the households' food budget was spent on street foods. This share was higher for poorer population segments.

In many developing countries the set-up of street stalls is unregulated. Stalls frequently lack adequate refrigeration, water, and sanitation facilities. Vendors are often not trained in preparing, handling, and storing food safely. Therefore, strong links between street foods and the prevalence of gastrointestinal infections have been detected in developing countries (Maxwell et al. 2000; FAO 2008). Globally, these infections are a major cause of morbidity and mortality, particularly among children.

Food access: Having sufficient resources to afford a healthy diet, is the most important dimension of food security in urban areas, because urban dwellers are net food buyers. In many cities of developing countries, inhabitants buy more than 90 percent of their food (Maxwell et al. 2000; Ruel and Garrett 2004). In addition, the poor spent the largest share of their disposable income on food purchases. This implies that, compared to rural areas, urban dwellers are more dependent on cash incomes; and thus employment opportunities. These many not be sufficiently available,

particularly in rapidly urbanizing small to medium-sized cities. As a consequence food prices play a major role in urban areas. According to Ruel and Garrett (2004, p. 39) urban food prices and expenditures depend on a) an efficiently operating food marketing, b) a households purchasing behavior, e.g. whether the household purchases in bulk, c) a household's opportunity to produce some of its food, e.g. through a home garden, d) a household's access to public transfers such as food subsidies or food aid, or private transfers through exchanges with family members. Maxwell et al. (2000) found that kinship systems in urban Ghana work less well compared to rural areas. And e) macroeconomic policies, including the availability of food subsidies and the ability to import food. As illustrated above these factors are often not given in rapidly urbanizing cities, which makes poor urban dwellers particularly vulnerable to changes in food prices.

3 Using food density maps to identify future food security hotspots

The 2007/2008 food crisis vividly demonstrated the vulnerability of the urban poor and the strong link between food and national security. When prices for staple food crops – like wheat, maize, and rice – started to rise at the end of 2007 and reached decade highs in early 2008, the urban poor were hit the hardest, because they heavily rely on food purchases and spent most of their income on food. Immediate consequences of food price increases were food-related riots and conflicts in urban centers of many developing countries, which endangered national security and toppled the government of Haiti. The underlying reasons of the food crisis are not to be discussed here, because they have been brilliantly debated elsewhere (see for example von Braun 2008).

Important in the context of this paper is that with the expected boost in urbanization and population growth, the food security situation in urban areas may worsen, if cities are unable to cope with the increase in their populations. This would make the urban poor more vulnerable to food price spikes. To avoid such kind of scenario, policy-makers will have to react to these risks by developing strategies that address the four dimensions of urban food security. Given limited resources, such strategies have to be efficiently directed at future food security hotspots. Food density maps can be one instrument in identifying these areas.

3.1 Food density maps: Definition and construction

Food density maps combine current and projected per capita food demand (cal/person/day) with current and projected population densities (people/km^2). This is displayed in geo-referenced maps,

which present food consumption density as calories/km^2/day. Food density maps consequently incorporate three main factors: i) population growth ii) growth in population densities and iii) growth in food consumption expressed in daily calories available per person per day (Schmidhuber and Müller 2008).

Given this definition, data on population growth, population densities and food availability were required for constructing food density maps. Population growth data for 2005 and projected population data for 2050 was retrieved from the United Nations (UN) population estimates. To receive data on population densities the UN data was adjusted to LandScan 2005. LandScan provides GIS maps of population densities with a resolution of 5 Arc Minutes, which corresponds to approximately 9X9 kilometres per grid cell (at the equator). In a next step, UN population estimates for 2050 were compared with the 2005 population estimates and growth factors were calculated. Finally, food availability is defined as the food that is directly available for food consumption and is expressed in calories per capita or dietary energy supply (DES). Information on food availabilities can be retrieved from national food balance sheets, which display a country's production of and trade in food commodities as well as non-food uses and loss of food commodities. It should be mentioned here that food availability data does neither reflect the actual food *consumption* nor the *accessibility* of food within a country (Bruinsma 2003). Food availability data for 2005 and projections for 2050 were made available from the FAO. For more information on the underlying assumptions for the projections, the reader is referred to Bruinsma (2003).

To construct the food density maps for 2005 population estimates were linked to LandScan and in a next step data of food availabilities for 2005 were joined with the population data to create the geo-referenced food density map for 2005. To create the food density maps for 2050, similar steps were taken. First, LandScan was adjusted for the calculated population growth factor to display population density in 2050. In a final step, DES projections for 2050 were combined with the population data in a geo-referenced map. The maps below present the final results. Given the size of these maps and the space limitations, only food density maps for Sub-Saharan Africa and South and East Asia are presented, because these two regions are projected to urbanize the most in the future. The maps were created by Josef Schmidhuber FAO and were made available to the author.

3.2 Results: Food density maps for Sub-Saharan Africa and South and East Asia

Figures 1 and 2 represent the food density maps for South and East Asia in 2005 and 2050,

respectively. What can be seen in Figure 1 is that food densities are already very high, particularly in Bangladesh, India, and China. This is largely explained by the population size in these countries, rather than a by high degree of urbanization. In Japan, on the other hand, Tokyo has a high food density, which reflects the high rate of urbanization.

Figure 2 reveals that in 2050, food density will become even more concentrated, particularly in China, Indonesia, India, and Bangladesh. The main driver behind these changes will be higher urbanization rates and population growth, because these countries have already achieved high levels of per capita food availabilities. The figure also reveals that particular pressure will be put on food systems in India's northeast and Bangladesh. If these are not operating effectively, these areas could become future food security hotspots.

(Figures 1 and 2 about here)

Sub-Saharan Africa, on the other hand, offers a very different picture: Here the food density levels are relatively low. Figure 3 displays that only in the capital cities of West Africa and in a few areas around Lake Victoria food density levels are high. Comparing the current situation with the projections for 2050 reveals that average food densities are projected to remain low and will continue to be equally spread throughout the area (see Figure 4). Yet, the maps suggest that there will be further growth in food density around the highly populated coastal areas of West Africa, particularly in Nigeria. This will be driven by urbanization. If urban areas are unable to adapt to these changing conditions, potential food security hotspots could evolve. In addition, there will also be higher food density in the high population-density areas of rural and urban east Africa, notably Ethiopia, Burundi, Rwanda, the Democratic Republic of Congo, and Uganda. Finally, it is projected that there will be broad increases in food density that includes many rural areas, including agriculturally marginal areas in large parts of the Sahel (Schmidhuber and Müller 2008).

(Figures 3 and 4 about here)

Finally, a word of caution: To-date food density maps have not been used widely. This is related to the extensive data that the development of such maps requires. Yet, different data sources and the use of projection data will impose some bias on the maps. For example, the dietary energy supplies are based on national averages. Moreover, the underlying assumptions for population projections may not be entirely correct. Yet, even though the food density maps may be biased, they certainly indicate the direction of developments and trends.

4 Conclusions

The objective of this paper was to outline the relationship between urbanization and food security and to compare food density maps for 2005 and 2050 in order to point out potential future food security hotspots. We found that urbanization has a profound effect on all dimensions of food security and that investments in city infrastructures will be particularly needed in small to medium-sized cities. Food density maps could be helpful and innovative instruments in pointing out potential food security hotspots, i.e. areas where pressure on food systems will be particularly high. We compared geo-referenced food density maps for South and East Asia and Sub-Saharan Africa. For both regions, urbanization rates are projected to be high in the future. We found that a number of rapidly urbanizing areas in sub-Saharan Africa and South Asia could become potential food security hotspots. Food density maps have not been used widely to date, which is related to their large data requirements. They could be developed further, particularly with respect to underlying data sources.

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Figure 1: Food density map of South and East Asia, 2005

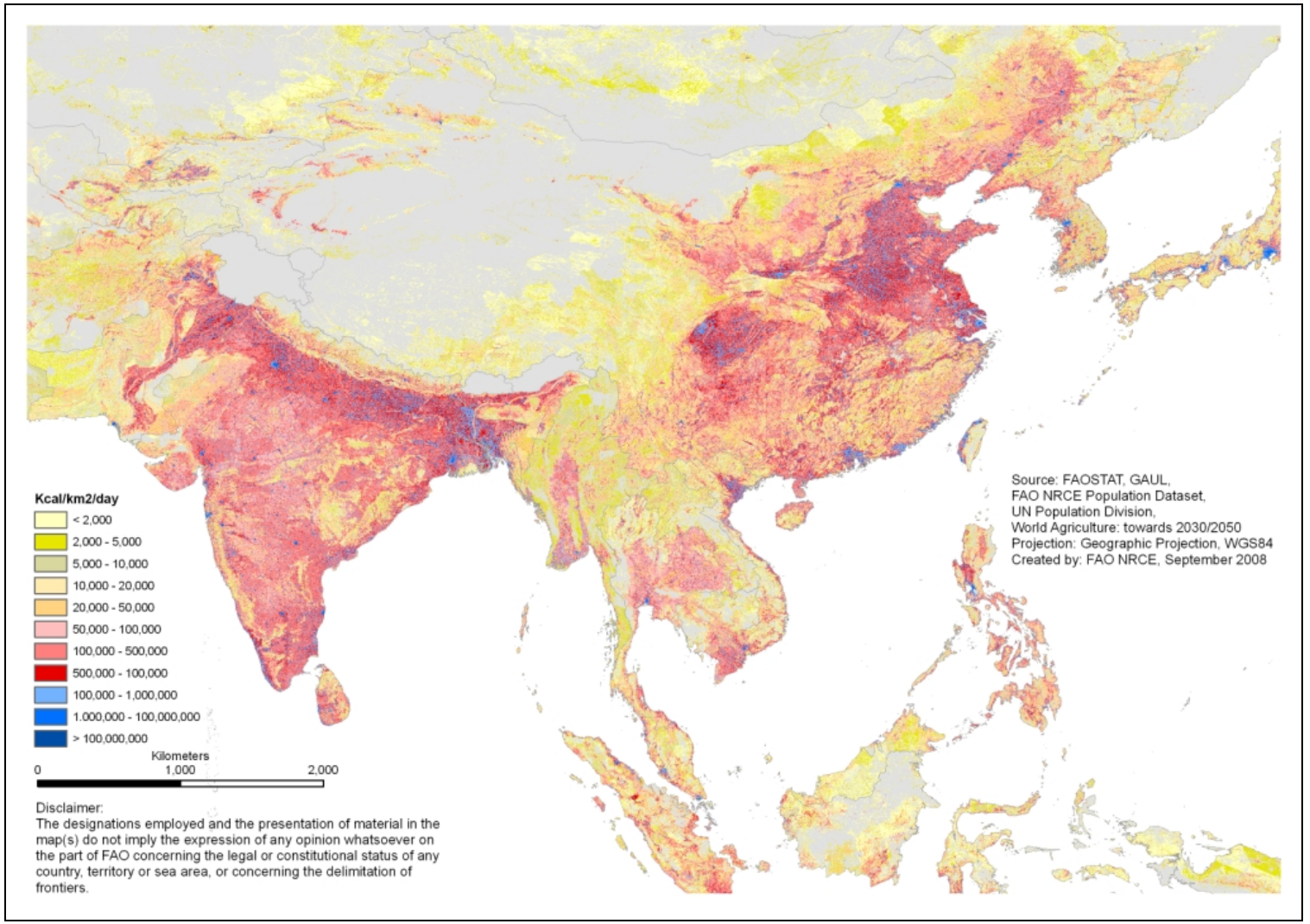

Figure 2: Food density map of South and East Asia, 2050

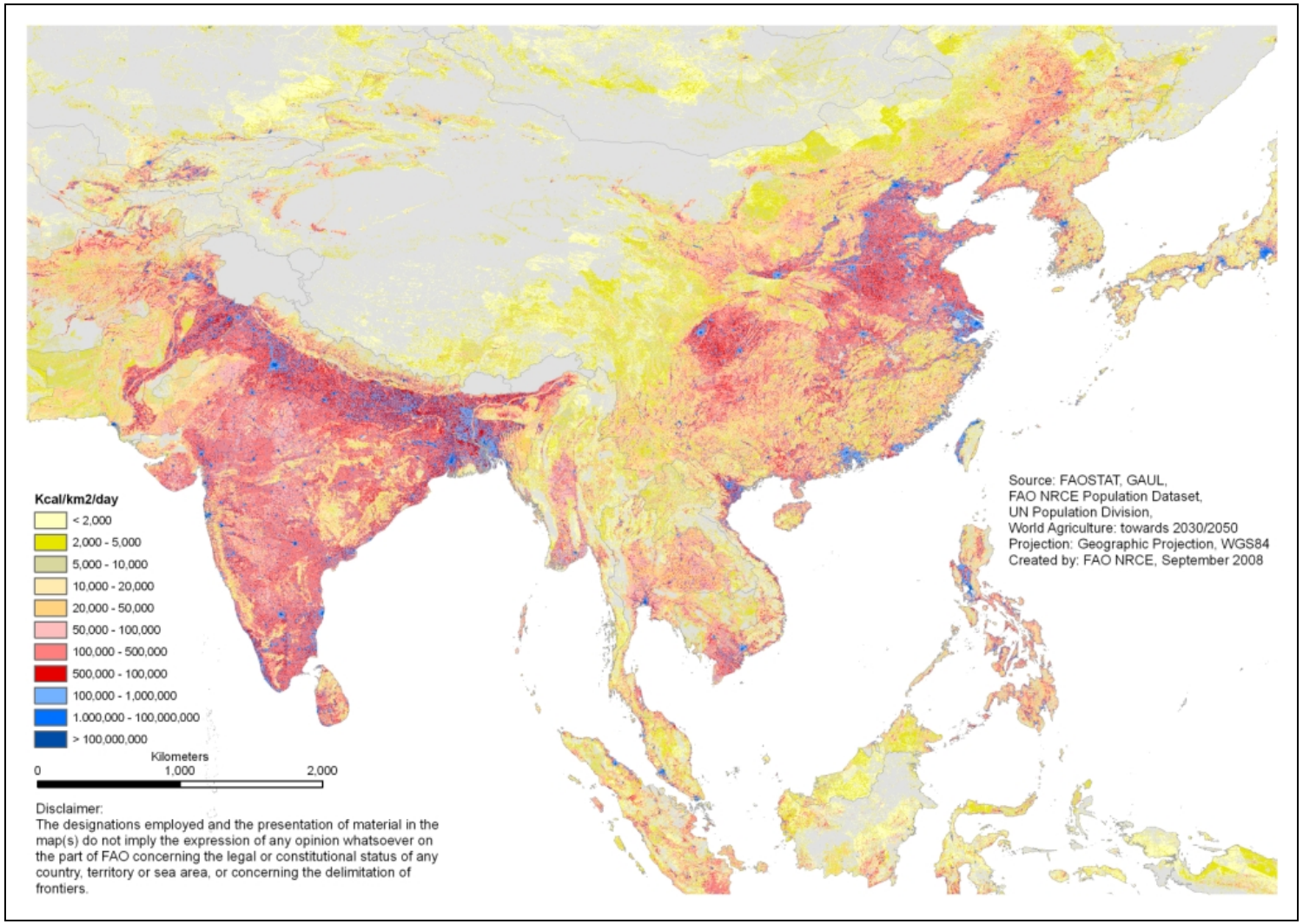

Figure 3: Food density map of Sub-Saharan Africa, 2005

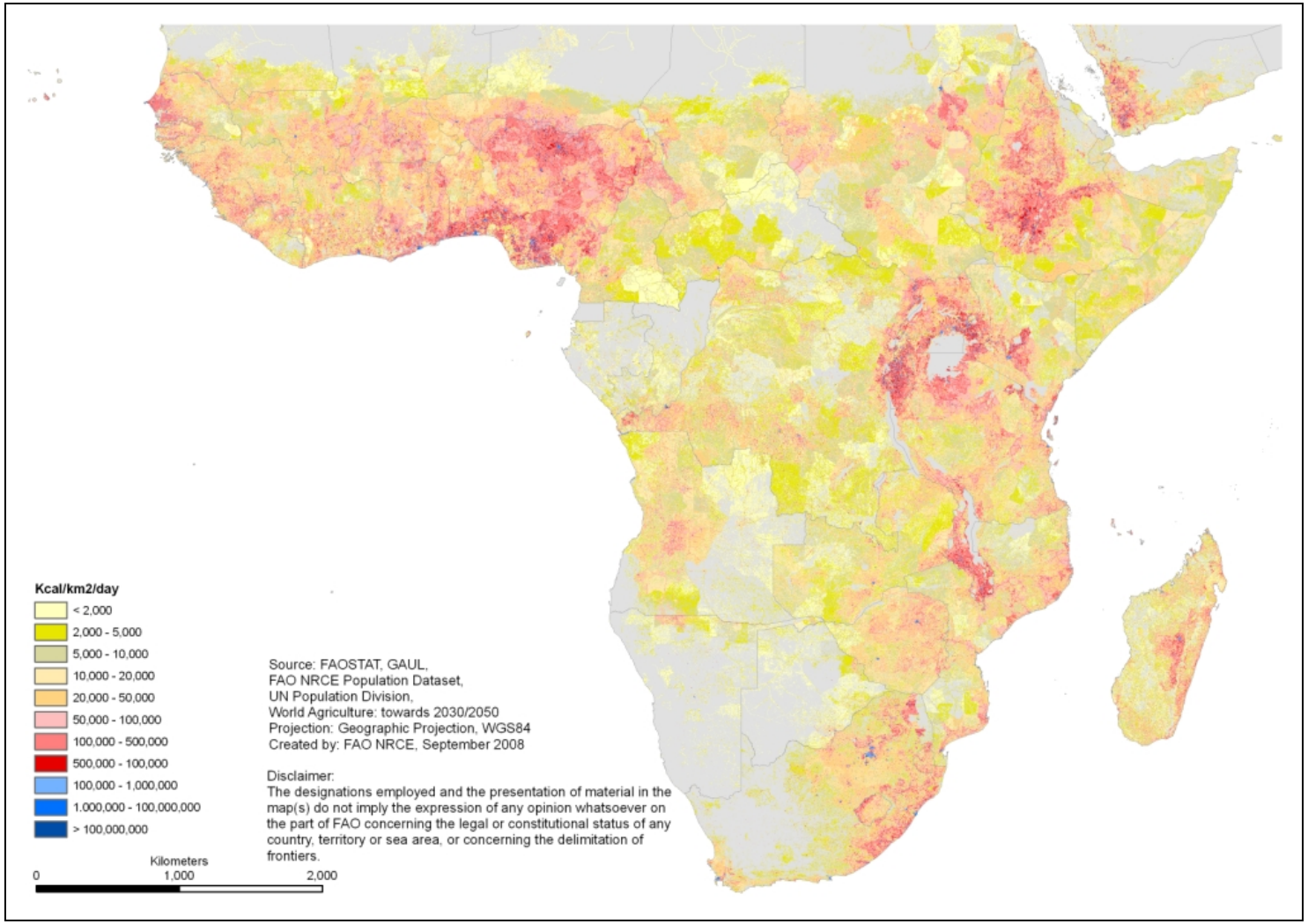

Figure 4: Food density map of Sub-Saharan Africa, 2050