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Steven W. Running
University of Montana - Missoula, steven.running@umontana.edu

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Perspective

A regional look at HANPP: human consumption is increasing, NPP is not

Steven W Running
Numerical Terradynamic Simulation Group, University of Montana, Missoula Montana USA 59812

Abstract
Abdi *et al* (2014 *Environ. Res. Lett.* **9** 094003), have adapted the concept of comparing supply and demand of annual plant production known as human appropriation of net primary production (HANPP) to a region of the Sahel with rapid population growth. They found that HANPP more than doubled over the study period of 2000–2010, from 19% to 41%, suggesting increasing vulnerability of these populations to food insecurity.

Keywords: net primary production, food security, carbon cycle

Few issues are more fundamental to our continued presence on Earth than the sustainability of human consumption of biospheric resources. This question is often approached as an input–output or a supply–demand analysis of the terrestrial carbon cycle, with the input, or supply being NPP, and the output, or demand being human consumption of that NPP. At a global scale, HANPP or human appropriation of net primary production attempts to quantify what fraction of NPP is used or co-opted by humans, a broad definition that includes not only direct consumption for food, animal feed or fuel, but also NPP used for broader human benefit. The first estimates, by Vitousek *et al* (1986) and (1997), estimated that humanity was using about 32–40% of global NPP. More recent global estimates are 14–26% by Imhoff *et al* (2004), and 13–25% by Krausman *et al* (2013). These studies have the same policy motivation, to evaluate if humanity is approaching some sort of capacity, or limit in consumption of the biosphere.

The new paper by Abdi *et al* (2014) is a great example of analyzing HANPP at a very policy relevant regional scale. At issue here is comparing the biophysically controlled annual plant production (NPP) to the actual demand and consumption of that plant matter by the local population with the explicit goal of understanding if this represents a sustainable local carbon balance. The area of study encompassed 22 countries of sub-Saharan Africa, across a rather spectacular climatic gradient ranging from 100 to 600 mm of annual rainfall. These are developing countries with high reliance on their own land for the food, fibre and fuel (i.e. HANPP) for their societies. Abdi *et al* report that in this sub-Saharan study region 95% of domestic food consumption comes from crops grown in this area, there is very little import or export of crops, such that the region is quite self-sufficient, either by choice or more likely by economic necessity. Consequently, a rather complete carbon cycle supply–demand analysis is possible and politically important in this region. Spatially extensive satellite based measures of NPP were used to define the *supply* of NPP on each 1 km^2 of land. Abdi *et al* then computed NPP *demand* for human food, fuel, animal feed, forest burning for land clearing, and crop residues (see figure 1). The policy critical result was that while NPP supply was on aggregate stable during the study period from 2000 to 2010, population increased 31%, HANPP increased from 19% to 41% of NPP supply,

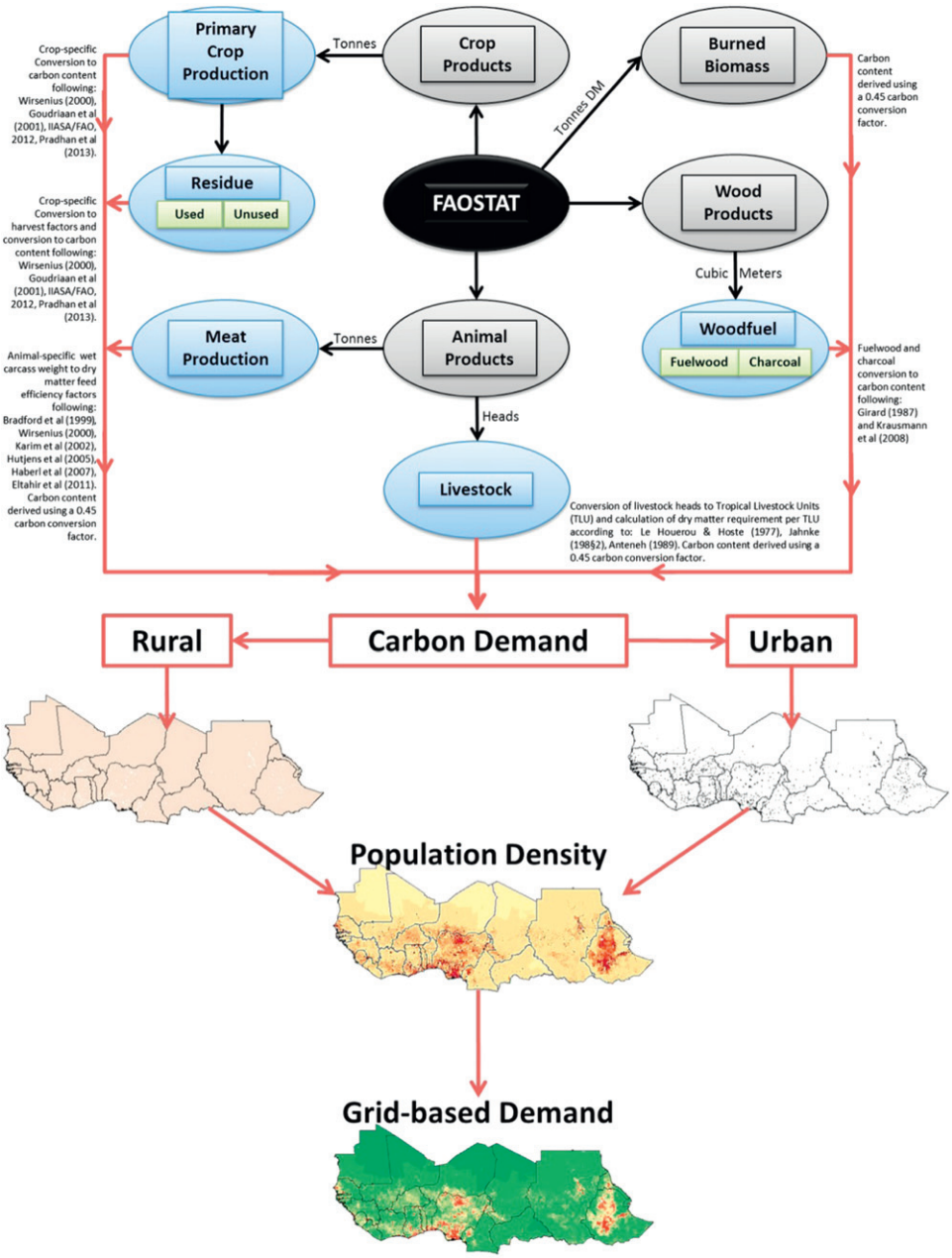

Figure 1. The datastream used to compute a regional scale HANPP from Abdi *et al* 2014.

and per capita available NPP declined. Most significantly, on critical drought years, such as 2002, NPP supply dropped 9.7% below the decadal average, triggering food insecurity issues for 12 million people.

Other studies have analyzed capacities of the terrestrial carbon cycle for human use with different methodologies but similar goals. Terrestrial carbon accounting has typically been focused on the biophysical carbon source-sink dynamics of ecosystem NPP at regional scales (Houghton 2013). Ecosystem services for carbon are an attempt to blend biophysical analysis with socio-economic analysis (Costanza *et al* 2014). The optimum scale for these carbon cycle analyses varies, from a single product, to a local land-owner, to national policies and finally global carbon budgets. But the key concept is understanding the carbon cycle in an integrated, policy relevant way that evaluates the system capacity for NPP against a variety of demands and economic values. I have argued previously that at global scales NPP shows little capacity to be increased

(Running 2012). Globally, little additional land can be made available for food production beyond what already is being used (Lambin and Meyfroidt 2011). However, agricultural efficiency can be greatly improved in many regions, and in fact could successfully feed the projected global population of 9–10 billion in 2050 with proper policy choices (Mueller *et al* 2012). Mueller *et al* (2012) report that increasing NPP supply in sub-Saharan Africa should focus most by addressing agricultural nutrient deficiencies. If a changing climate brings more intense drought episodes, water management will be even more important. The largest unknown is new demands on terrestrial NPP, most notably large scale bioenergy, which may provide a direct competitor to food production in the regions that can least afford it (Smith *et al* 2012, Haberl *et al* 2013). Mueller *et al* (2012) and Abdi *et al* (2014) both recommend more efficient cooking stoves as a viable way to reduce bioenergy demand in this region.

The concept of HANPP originated as a global analysis, but regional applications such as the Abdi *et al* paper may in fact be more valuable for policy development by individual governments. The regional HANPP trend analysis can quantify increasing vulnerability of the local populations to any shortfall in NPP as demand approaches supply, an early warning system. Local policies to either increase NPP supply, or to reduce NPP demand may be better prioritized. Similar regional studies would be valuable in other parts of the world.

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