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Global land availability: Malthus versus Ricardo

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ABSTRACT

Extensive and rapid conversion of productive lands around the world in response to multiple demands for land raises the concern that we risk running out of productive land globally. I discuss two competing views on the global availability of productive land. In an interpretation of a Malthusian view, a limited stock of suitable land leads to a strict competition between land uses and, eventually, to a shortage of productive land, with negative welfare impacts. In the Ricardian view, it becomes economically feasible to bring marginal land into use as prices of land-based commodities increase. Even though the stock of suitable land is finite, a geographic redistribution of land use, trade, and investments in land resources give access to more resources, but it comes at ever increasing economic, environmental and social costs. Global food security increasingly involves trading off food for nature.

1. Introduction

Access to land with high agro-ecological suitability is an essential component of global food security: at a global scale, suitable land is likely to become the factor of production in shortest supply for agriculture. Despite a continuous increase in the productivity of agriculture and forestry, the pressure to convert more land remains high, raising concern for a looming land scarcity (Lambin and Meyfroidt, 2011). Globally, crop production has benefited from a steady yield increase (Godfray et al., 2010). In forestry, a greater production per hectare has been achieved both through increasing tree density (Kauppi et al., 2006) and productivity (Carle and Holmgren, 2008). While technological innovation will continue to push land productivity upward, eventually this progress may fall prey to the law of diminishing returns. The exact timing of any future slow down in yield increase will depend on, for example, the potential of genetic manipulations of plants to drive further land productivity increases. Some inputs may also become limiting: the additional area of cropland that can be irrigated every year is limited by water supply. While irrigation efficiency improvements can reduce water consumed by agriculture (e.g., by about 13% in California, Christian-Smith et al., 2012), it can only push back rather than remove physical thresholds in water use. Crop yield increases are already slowing down in several Asian countries (Lobell et al., 2009). Moreover, the terrestrial net primary (plant) production (NPP) may be fixed by planetary constraints on a global scale – i.e., by energy input, precipitation, mass flows, – thus limiting the potential for substantial plant growth in the future (Running, 2012). Finally, agricultural intensification has externalities: it has on-site and downstream impacts on terrestrial, freshwater and marine ecosystems through various forms of pollution (Matson and Vitousek, 2006); and, if it involves mechanization, it frees up labor that may migrate and convert more land to low-input agriculture.

Human population growth and increases in per capita consumption will continue to lead to a growing demand for commodities produced from the land. Some commodities whose production occupy vast amount of lands, such as beef and soybean, have high income elasticity, and to a lesser extent, high price elasticity: as incomes increase and prices decrease, the demand for these goods increase rapidly, notably in emerging economies. As long as the rate of increase in demand will be greater than the rate of productivity increase, a conversion of land under natural vegetation cover to productive uses will be unavoidable – unless demand switches towards goods whose production is less land-intensive.

Multiple demands for land cumulate to lead to rapid conversion (Smith et al., 2010): demand for more cropland to increase food and biofuel production; for industrial forestry to produce timber; for fast growing tree species for carbon sequestration; and for urban and recreational spaces to accommodate a growing urban population. Moreover, demand for protected areas for nature and biodiversity conservation, and for natural or managed ecosystems to provide a range of ecosystem services further contribute to a potential conflict between various land uses. The

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additional land demand for all agricultural, bioenergy, tree plantation, urban and nature conservation uses was estimated to range from 285 to 792 Mha by 2030 compared to the 2000 baseline (Lambin and Meyfroidt, 2011), under scenarios that include significant land productivity increases and abandonment of degraded lands.

These additional land demands often compete for the most productive and accessible lands, that are least vulnerable to natural hazards and climatic variability, and where a skilled labor force is available and political stability favors productive uses and long-term investments in infrastructure. Additional land demand also targets suitable lands that are currently underutilized, except for the fact that these lands often provide a full array of ecosystem services that are essential for local communities and for the productivity of their farming systems. At the same time, various forms of land degradation are causing continuous losses of productive land. Moreover, climatic change is likely to alter the comparative advantage of land in many parts of the world: agricultural lands that are currently productive will become marginal while some high latitude areas will become more suitable for agriculture. Converting the latter will be associated with constraints and ecological and social trade-offs however.

Are we running out of productive land? The objective of this article is to discuss two different views – a Malthusian and Ricardian view – on the global availability of productive land. A crude ‘‘Malthusian’’ view refers to the assertion that resource depletion and scarcity occur when the rate of resource consumption outstrips the ability to provide new resources, thus leading to a crisis. Population equilibrates with resources at a level that is mediated by technology and a conventional standard of living (Lee, 1986). Malthus did not address explicitly the issue of land scarcity. I therefore refer here to an interpretation of Malthus. David Ricardo, a contemporary of Thomas Malthus, is best known for his law of comparative advantages, but also formulated the law of rent, which states that the rent of a land site is equal to the economic advantage obtained by allocating the site to its most productive use, relative to the advantage obtained by using marginal land for the same purpose, given the same inputs of labor and capital. According to Ricardo’s theory, under conditions of land scarcity and relatively inelastic demand, an increase in the amount of goods produced from land requires that the price of these goods increase to make it economically feasible to bring marginal land into use. I first discuss briefly the metaphor of ‘‘peak land’’, and then I outline the rationale underlying the two competing views, to finally examine empirical evidence in support of each of these views.

2. Land’s soil as a renewable resource

The concept of ‘‘peak resource’’ is increasingly being applied to any resource whose supply is becoming scarce. It seems common wisdom that, with increasing demand, the scarcity of any finite resource rises, at prevailing prices. For example, concerns about peaking world oil production are based on a logistic curve representing production rate as a function of time. The peak corresponds to the date when production is at its highest, and is followed by a phase when supplies become depleted more rapidly than production from new discoveries can be brought on line, leading to an exhaustion of the resource (Gorelick, 2010). The ‘‘peak land’’ metaphor may be attractive as the global land area is finite. Most land uses however – except for urban – rely on the soil, which is a renewable resource: soil quality can be enhanced and restored through management, making it possible to reuse land. The reasoning behind peak production does not apply to renewable resources: a ‘‘peak’’ in resource production followed by a decline is only possible for non-renewable resources. However, the concept of ‘‘peak ecological water’’ has been proposed, despite it being a renewable resource: it occurs at a point where the value of ecological services provided by water is equivalent to the value of human services satisfied by that same use of water (Gleick and Palaniappan, 2010). After this point, additional water use causes serious or irreversible ecological damage. The concept of ‘‘peak timber’’ has also been proposed, given that the standard cutting cycle in logging operations in tropical forests is often too short to allow the wood volume to regenerate (Shearman et al., 2012).

Land use rarely leads to an exhaustion of the resource as, with appropriate investments in productivity maintenance, land can be kept under use indefinitely. In this case, the rate of land conversion is only driven by incremental demand above the baseline. Only a catastrophic scenario of a widespread, continuous and irreversible degradation of the productive capacity of lands under use, or of an extreme and prolonged drought akin to the Dust Bowl affecting one of the major food producing regions of the world could lead to a true ‘‘peak land’’ – though it would only be temporary in the latter case. Indeed, a volcanic eruption or tsunami could also create land shortage but only locally and in the short run. Therefore, peak land – or peak soil for that matter – seems to be an inappropriate metaphor.

Similar to non-renewable resources characterized by a peak production, land conversion also follows a logistic curve at the scale of decades to centuries. Actually, one observes a rapid rate of conversion of highly productive land with initial increases in demand, until a time when finding new productive land that is both available and accessible becomes more challenging and the rate of conversion of the most suitable land decreases for a lack of supply of it. With the appropriate economic and institutional incentives, and provided that the technology is available, it gives rise to an intensification of land use, thus increasing land productivity *à la* Boserup (Boserup, 1965). Another pathway can result however if increases in demand for land-based resource are increasingly met through the conversion of marginal, less productive land, which leads to a less than proportional increase in production. In some cases, marginal lands can be made into productive lands with the appropriate investments (e.g., in terracing or drainage) (Turner and Ali, 1996).

3. Malthusian versus Ricardian views of land

3.1. Malthusian view of land

In a Malthusian interpretation, the finite stock of suitable land leads to a strict competition between land uses. Eventually, land area is insufficient to meet demand given the current technology, which causes a decline in welfare. The land area that can be used for human needs is limited by climate, topography and soil characteristics. Land limitations are specific to certain uses (e.g., forestry, crop production, and livestock) and specific crops or tree species. Land suitability also depends on the level of input use, input type and on management. The global availability of land with a good agro-ecological suitability is still poorly quantified. The total ice-free land area covers 13,300 Mha, only about a quarter of it being suitable for rain-fed agriculture given temperature, rainfall and soil constraints. Of this, about 1500–1,600 Mha is already under cultivation (Ramankutty et al., 2008). Early estimates of the amount of land available for future expansion of cultivation ranged from 1670 to 1900 Mha, depending on the method used (Young, 1999). These high values dispelled the notion that most high quality land had long been converted. More recent estimates of the potential land reserve however have significantly revised these figures downward. A