THE EVOLUTION OF GLOBAL FARMING LAND: FACTS AND INTERPRETATIONS

(June 2015)

Derek D. Headey
Senior Research Fellow,
The Poverty, Health and Nutrition Division
The International Food Policy Research Institute (IFPRI), Washington DC

Abstract

Although land plays a crucially important role in economic development and structural transformation, the causes and consequences of the evolution of farming land have only been paid scant attention in recent decades. In this paper I document changes in the extent of global farming land and in average farm sizes. I show that the spatial distribution of global farming land has changed dramatically, with developed countries substantially reducing their share and land-abundant developing countries substantially increasing their share. In per capita terms we see a rather different pattern, with average farm sizes increasing rich and more commercialized agricultural systems, and generally declining or staying constant in poorer and less commercialized systems. These outcomes are the result of complex processes that are not always well understood. I conclude the paper by suggesting new, or neglected, areas of research that would help us better understand these critically important developments.

Key words: Farm land, land use, agricultural development.

1. Introduction

It is difficult to understate the importance of land in agricultural development. Most obviously, the extent and quality of agricultural land is a fundamentally important input into agricultural production. But as Boserup and her followers amply illustrated, land endowments have much more far-reaching effects on agricultural production pathways and technology adoption, as well as on markets for land, labor, inputs and capital (Boserup, 1965, Ruthenberg, 1980, Ruttan and Hayami, 1984, Binswanger and Rosenzweig, 1986, Binswanger and McIntire, 1987), as well as migration and perhaps even fertility behavior (Headey and Jayne, 2014). Since the early 1990s both economists and natural scientists have paid more attention to the environmental consequences of land use, with agricultural land use clearly shown to have been one of the major drivers of deforestation and climate change (Angelsen and Kaimowitz, 2003, Meyfroidt, et al., 2010, Byerlee, et al., 2014). And more recently, the surge in food prices in the mid 2000s appears to have catalyzed renewed public and private interest in acquiring land, including large "land grabs" in developing countries (Schoneveld, 2014).

Yet outside of the sizeable literature on the environmental consequences of agricultural expansion, the causes and consequences of the evolution of farming land have only been paid scant attention in recent decades, perhaps because – over the short run – farming areas change relatively slowly (recent "land grabs" not withstanding). However, over the medium term – the course of several decades – the global distribution of farming land has changed radically, with far reaching consequences for agricultural production and trade, economic development and poverty reduction, and environmental sustainability. In this paper I am to document and explain these changes as a series of stylized facts characterized at a relatively aggregate levels (e.g. regions, continents, levels of development), with the objective of analyzing changes in the forest rather than the trees. Methodologically I mix together some fresh analysis of familiar datasets - particularly FAOSTAT and also the *World Programme for the Census of Agriculture* - with some review of the existing literature on land use changes in agriculture, and the implications of these changes for economic transformation, poverty reduction and environmental sustainability. I also mostly describe extensive changes in land area, not more intensive use of land, although I do focus on the interaction between the two where relevant. Finally, I adopt a long term lens, reviewing historical studies that reach back over several centuries, descriptive data from the FAO and other surveys that go back several decades, more recent studies that focus on land use changes over the past decade or so, and prospective analyses of land use change under plausible future economic and climatic scenarios.

The remainder of the paper is structured as follows. Section 2 examines changes in agricultural land area at a global and regional, and uses both informal and econometric analysis to understand why agricultural area has evolved in this fashion, and what the future holds. Section 3 instead looks at patterns and changes in farm land per capita, with a particular focus on the welfare (poverty) impacts of declining farm sizes in developing countries.

2. Changes in agricultural land area

Agricultural development in recent centuries has undoubtedly had a profound impact on the global landscape. Using two different historical data sets, Klein Goldewijk and Ramankutty (2004) estimate that cropland areas expanded from 3–4 million km^2 in 1700 to 15–18 million km^2 in 1990 (mostly at the expense of forests), while grazing land area expanded from 5 million km^2 in 1700 to 31 million km^2 in 1990 (mostly at the expense of natural grasslands). All in all, agricultural area expanded by 80 percent over this time period, or about 39 million km^2; an area 2.4 times as large as Russia. Most of that expansion occurred in the 20th century alone, with cropland area expanding by 50 percent during the 20th century in net terms. Ramankutty, et al. (2002) show that most of the expansion in cropland from 1900 to 1930 took place in the American corn belt, the Canadian prairie, south-western Australia, the Argentinean pampas, the Brazilian interior and southwestern Australia. From 1930 to 1960 there was continued but more modest expansion in these land abundant regions (and some decline in the Eastern seaboard of the US and parts of Western Europe), though a more significant expansion occurred in terms of the “virgin lands” project in the Former Soviet Union, which led to an eastward expansion of cropping area. Cropland expansion also started to accelerate in South-East Asia with the development of cash crops, notably rubber and oil palm. From 1960 to 1990, land area changed relatively little in the more developed economies of the global, with most of the net increase at the global level resulting from land expansion in South America, South-East Asia and sub-Saharan Africa. The “Green Revolutions” in rice, wheat and maize also promoted some significant land expansion (and intensification) through most of Asia from the late 1960s to the mid 1980s, while agricultural reform strongly coincides with a rapid expansion in land area in China, with crop area growing by 15 percent from 1977 to 1987 (FAO, 2014).

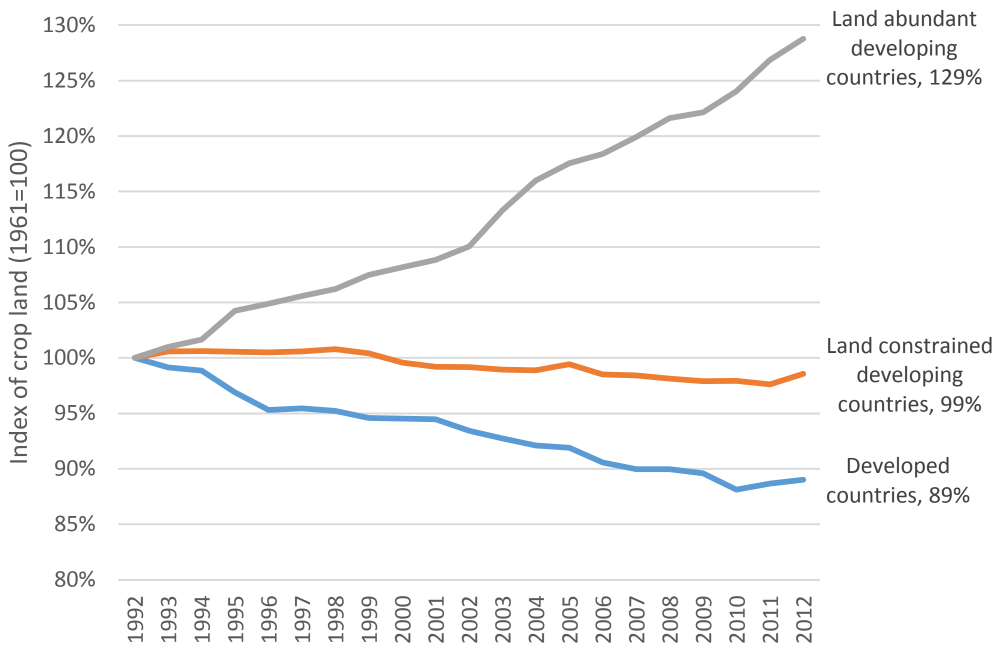
Less widely discussed in these historical studies of land use change are trends over more recent decades. In Table 1 I report trends in both cultivated land (arable land plus permanent crops) and more sketchy estimates of pastoral land (permanent meadows and pastures) for two time periods: 1961-1990 and 1990-2012. In Figure 1 I aggregate even further by group regions into one of three countries: developed (North America, Europe and Oceania), land abundant developing (South America, South East Asia and sub-Saharan Africa) and land constrained (South Asia, East Asia, Middle East and North Africa, Central Asia, Central America). In Figure 2 I show how the rapid expansion of crop land in land abundant developing regions has led to a major shift in the global distribution of crop land. Together, Table 1 and Figures 1 and 2 point to notable stylized facts. First, the late 1980s and early 1990s were a time of substantial transition in farming systems, with some significant regional changes in land expansion/contraction (Table 1). Second, Figure 1 land expansion in land abundant developing regions has been phenomenally fast in recent decades (Figure 2). Finally, an implication of land expansion in these regions is that the global distribution of agricultural land has shifted markedly, particularly crop land (Figure 3): the share of global crop land in land-abundant developing countries has increased from just 22% in 1961 to 34% in 2012, and who knows where it will end.

Table 1. Changes (%) in farming land by region, and some speculative explanations

Region	Area	1961-1990	1990-2012	Potential Explanations
Sub-Saharan Africa	Pastoral	0.1%	4.6%	Sustained population growth; relative land abundance in some countries; structural adjustment reduced distortions to agriculture, making it more profitable.
	Cultivated	19.3%	40.3%	
	Total	3.1%	11.2%	
South Asia	Pastoral	7.8%	-0.5%	Green Revolution fueled modest land expansion in 1960s and 1970s, but the region faces major land constraints and pursues intensive agriculture.
	Cultivated	-4.4%	-2.1%	
	Total	5.2%	-0.8%	
South-East Asia	Pastoral	3.4%	2.3%	Green Revolution fueled some expansion, but major expansion due to oil palm and other cash crops.
	Cultivated	26.3%	34.1%	
	Total	21.9%	28.9%	
East Asia	Pastoral	26.5%	5.4%	Green Revolution fueled modest land expansion, but major land constraints; rapid economic transformation causing conversion of farm land to nonfarm uses
	Cultivated	19.2%	-4.8%	
	Total	24.8%	3.1%	
Latin America	Pastoral	14.8%	6.0%	Green Revolution in wheat and maize in 1960s & 1970s; soybeans & cattle in Brazil, including expansion of *Cerrado*.
	Cultivated	42.6%	32.2%	
	Total	19.8%	11.6%	
Middle East, North Africa	Pastoral	6.6%	21.9%	Sustained population growth; land abundant but water constrained; increased demand for livestock leads to larger growth in pastoral lands.
	Cultivated	11.9%	12.0%	
	Total	7.6%	19.9%	
North America	Pastoral	-8.8%	3.2%	Structural transformation out of agriculture; modest land conversion to protected areas and other uses; declining real food prices.
	Cultivated	2.8%	-13.8%	
	Total	-3.5%	-5.0%	
Eastern Europe & Central Asia	Pastoral	8.0%	8.3%	Structural transformation out of agriculture; political and economic reforms of the 1990s eliminated large, inefficient state farms; declining real food prices.
	Cultivated	-3.6%	-16.2%	
	Total	2.5%	-2.6%	
Western Europe	Pastoral	-8.8%	-10.7%	Structural transformation out of agriculture; modest land conversion to protected areas and other uses; declining real food prices.
	Cultivated	-8.2%	-6.1%	
	Total	-8.5%	-8.0%	
Australia & New Zealand ("Oceania")	Pastoral	-1.4%	-15.8%	Structural transformation out of agriculture since 1980s; climate change and drought reduced pastoral land; declining real food prices; collapse of the wool sector.
	Cultivated	48.6%	-2.2%	
	Total	2.2%	-14.4%	

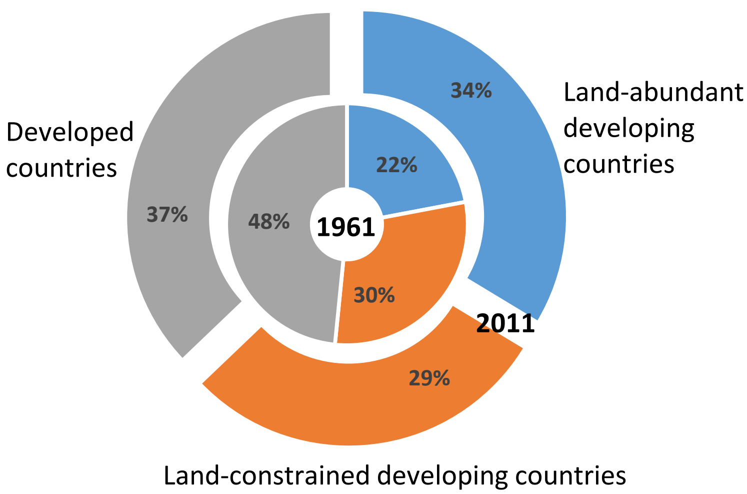
Notes: Author's estimates from FAO (2014) data.

Figure1. Changes in cultivated land in land-abundant developing countries, land-constrained developing countries, and developed countries: 1992-2008



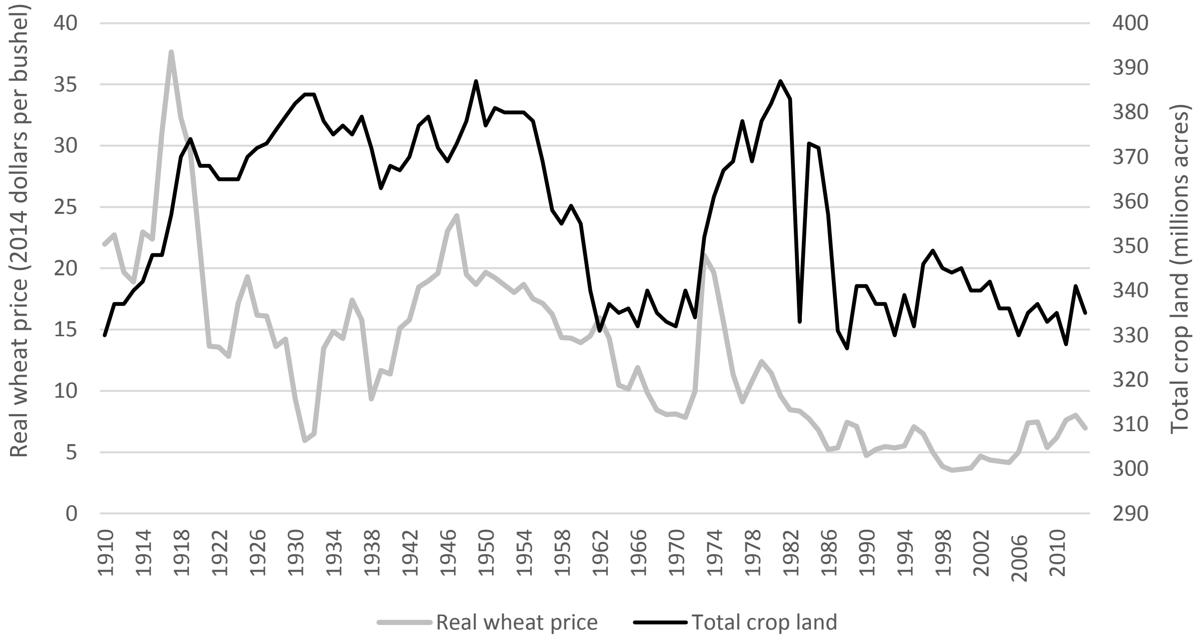
Source: Author's estimates from FAO (2014) data.

Figure 2. The changing global distribution of farming land: 1961 and 2012



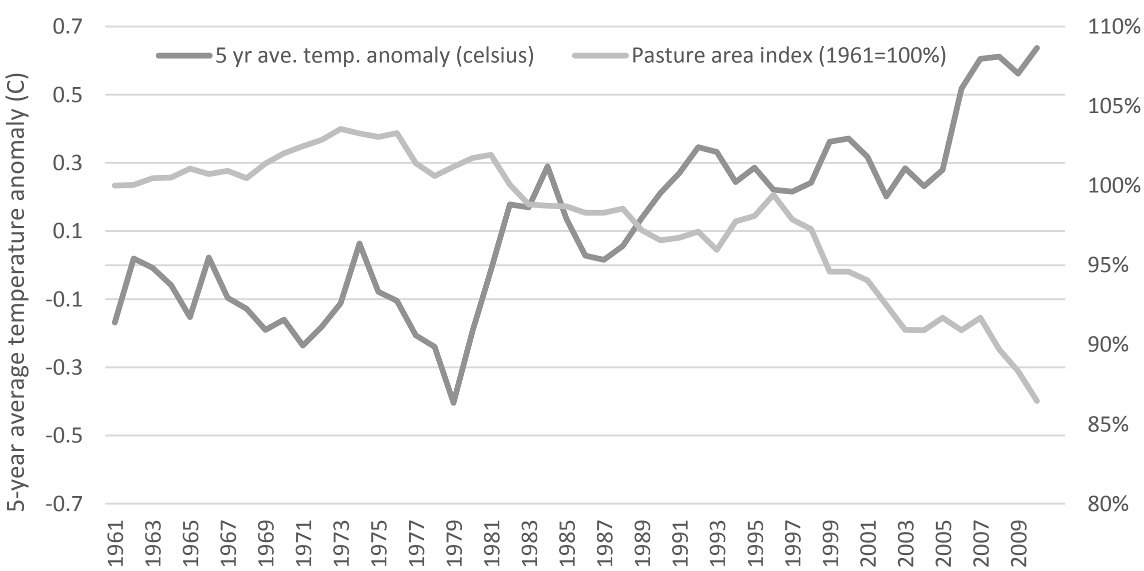
Source: Author's estimates from FAO (2014) data.

Figure 3. Trends in US crop land and real US wheat prices (millions of acres)



Source: Author's estimates from the United States Department of Agriclture (USDA) data.

Figure 4. Climate change and permanent pasture area in Australia



Source: Data on 5-year temperature anomalies are from the Australian Bureau of Meteorology, and pasture area data refer to "permanent meadows and pasture" land from the FAO (2014).

What's driving changes in farming land since the 1990s?

Starting with the first of these facts, what factors explain the rather different patterns and trends in land expansion/contract since 1990? One factor may be changes in agricultural prices, and their underlying drivers such as productivity growth. After relatively high agricultural commodity prices in the 1970s, food prices declined throughout the 1980s, which surely weakened incentives for engaging in farming (even with generous price support policies). Figure 3 shows the strong association between food prices and crop area in the United States. The effect of declining prices – along with demographic factors, such as ageing, and economic factors, such as rising wages and the increased profitability of labor-substituting technologies – was, in all likelihood, to make farming a less attractive and less labor intensive activity. Indeed, FAO data suggest that the population primarily dependent on agriculture to earn a living declined by an astonishing 61% in Europe, and almost 40% in North America.

In several more developed regions more idiosyncratic events also matter. In the former Soviet bloc countries the very sudden transition to market based economies had a profound effect on agriculture, including privatization of collective farms and the abandonment of unproductive lands (Swinnen, 2001). In Australia the collapse of the mismanaged wool sector coincides with a marked decline in pastoral area, though Figure 4 also suggests that climate change may have played a role in reducing the profitability of livestock production in a relatively water constrained agricultural system. Indeed, Australia appears to have experienced adverse climate change well prior to the well known "millennial drought", which was widely cited as a contributing factor to the 2007-2008 food price spike (Headey and Fan, 2008).

In developing regions, the 1960s, 1970s and 1980s saw land expansion even in land constrained developing regions (e.g. South Asia, China), but land expansion evidently reached a ceiling in these regions by the 1990s. Indeed, after a fairly rapid expansion of cropland area during China's early agriculture reforms (crop area grew by an estimated 15% between 1977 and 1987), crop area started to decline by the early 1990s, and the agricultural population is now thought to be declining quite markedly (Zhang??). In South Asia, crop area has remained more or less stable.

In contrast, land abundant developing regions saw rapid land expansion in both the 1960-1990 and 1991-2012 periods, though with somewhat different drivers. In Latin America (predominantly Brazil and Argentina), crop area increased by 42.6% and 32.3% in each period, respectively, but explosive growth in soybean area began with China's liberalization of agricultural imports in the mid 1990s and early 2000s (including WTO accession in 2001). In South-East Asia, crop area increase by a similar margin. In both cases commercialized export-oriented farming was the major driver of crop land expansion (Byerlee, et al., 2014). In South-East Asia oil palm has been the major driver of land expansion and deforestation. In the case of Brazil, expansion into the Amazon rainforest is perhaps the better known and more tragic manifestation of this process, but the conquering of the Brazilian *Cerrado* region has been the larger source of crop land expansion. Brazil's *Cerrado* experience is potentially also a blueprint (for better or worse) for analogous savannah ecosystems in sub-Saharan Africa, especially since it was African grasses which were adapted for *Cerrado* pastoral systems (The-Economist, 2010).

In sub-Saharan Africa the rate of expansion of farming land reported by FAO has also been impressive since 1990 or so, but these estimates should also be treated with much more caution. Statistical systems in Africa are much weaker than in other regions. That said, remote sensing studies of land cover change support the observation that agricultural land expansion has been rapid in aggregate. Brink and Eva (2009), for example, estimated a 57% increase in agriculture area from 1975 to 2000; a rate much faster, indeed, than FAO estimates. Expansion of crop land in sub-Saharan Africa is likely heavily driven by the continent's exceptionally rapid population growth, though economic changes should not be discounted. Indeed, if the FAOSTAT data are to be believed, growth in cultivated area accelerated very rapidly between the two periods analyzed in Table, from a 19.3% expansion over 1961-1990 to a 40.3% expansion in the shorter 1990 to 2012. One potential explanation of this acceleration is the widespread economic reforms that took place as part of the structural adjustment processes, particularly the scaling back of heavy taxation of the agricultural sector (Anderson and Masters, 2009). For example, farmgate cotton prices in Burkina Faso doubled in the 1990s, coinciding with an unsurprisingly rapid expansion in cotton area (Kaminski, et al., 2011). More recently, land expansion in African seems sensitive to the increase in global food prices, and to an acceleration in land areas devoted to more commercial farming systems, be it domestic "emergent farmers" (Sitko and Jayne, 2014) or foreign agricultural investors (Schoneveld, 2014).

In Table 2 we try to test out some of these hypotheses in what is admittedly a very non-structural or reduced form model in which crop land changes over 4-year periods are modelled as a function of lagged fertility rates (demographic pressures), changes in real domestic food prices, a dummy variable for whether current agricultural land is less than 25% of potentially arable crop land (since graphical evidence suggested a threshold effect), several indicators of infrastructure and market access (travel times to cities, shipping costs), several indicators of crop intensification potential (lags of irrigation, cropping intensity, and crop value per hectare) and lagged GDP per capita to capture basic levels of economic development. We also run estimates for the total sample of countries (excluding countries with small population or small land area) before splitting this sample up into more commercialized economies and less developed economies.[1] Note, also, that all regressions include time trends, but no fixed effects (since several explanatory variables are not time-varying), and all regressions are estimated with the non-parametric robust regressor, which downweights outlying values. Finally, a word of caution: the regressions in Table 2 are exploratory in nature; a range of misspecification problems could mean that the coefficients are biased.

Bearing that caveat in mind, what do we find? First, consistent with expectations, population pressures are a large and significant driver of land expansion. An extra child raises the 4-year growth rate of crop land by 0.65 to 0.80 percentage points, depending on the sample.

Second, changes in domestic food prices are also associated with crop land expansion, although not in the commercialized economy sample. This may be because commercialized agriculture is more sensitive to international prices (captured in the time trends) rather than domestic prices. However, even the magnitudes of the significant coefficients effect are quite small, although this may be due to measurement error (attenuation bias).

[1] The latter consists of low and low middle income countries according to the World Bank definition, and the former consists of upper middle and upper income countries.

Table 2. Exploring some of the associations with expansion of crop area

Regression number	1	2	3
Sample	All	Commercialized economies	Less developed economies
Fertility rate, t-1	0.653***	0.798**	0.707*
	(0.229)	(0.318)	(0.379)
Change in domestic food prices (%)	0.025**	-0.002	0.036**
	(0.010)	(0.015)	(0.014)
< 25% of potential cropland used (0/1) , t-1	2.563***	1.604	2.806***
	(0.647)	(0.984)	(0.995)
25-50% of PAC used (0/1) , t-1	0.698	1.042	0.039
	(0.604)	(0.801)	(0.994)
Rural areas < 2 hrs to 50K city (%)	-0.052***	-0.023	-0.074**
	(0.014)	(0.017)	(0.033)
Shipping costs index (rank 1-174)	-0.018***	-0.003	-0.027**
	(0.007)	(0.009)	(0.011)
Area equipped for irrigation (%), t-1	-0.039**	-0.019	-0.055***
	(0.015)	(0.026)	(0.021)
Cropping intensity (%), t-1	0.033***	0.026*	0.037***
	(0.008)	(0.015)	(0.010)
Log crop production per hectare, t-1	0.999**	0.566	0.868
	(0.496)	(0.766)	(0.744)
Log of GDP per capita, t-1	-0.462	-0.766	0.728
	(0.349)	(0.609)	(0.614)
Constant	-3.806	-0.548	-10.521
	(4.774)	(7.217)	(7.412)
R-squared	0.267	0.166	0.245
N	593	284	309

Notes: These estimates are based on a panel of four-year changes in crop land (arable land and permanent crop area in the FAOSTAT). *, ** and *** indicate significance at the 10%, 5% and 1% levels significantly, and standard errors are reported in parentheses. Results are estimated using the robust regressor (rreg command in STATA).

Third, as expected, the ratio of actual to potentially arable cropland is highly significant. Countries with less than 25% of their potential crop land under current exploitation are likely to have much faster expansion: a full 2.56 percentage points in the full sample. The effect is only statistically significant among less developed economies, although the coefficient for the commercialized economy sample is only marginally insignificant at the 10% level, and still relatively large in magnitude. Thus, land availability does seem to be an important driver of expansion.

Third, the market access indicators have significant and expected signs, especially in the less developed economy sample. The result is consistent with both domestic and international commercialization of agriculture being a major driver of cropland expansion.

Finally, cropping intensity indicators yield somewhat diverse results. Irrigated area predictably is associated with lower growth rates in crop land area, but lagged cropping intensity and lagged value per hectare are associated with faster growth in crop land area.

What are the implications of land expansion in land abundant regions?

Figure 2 demonstrated that the share of crop land in land abundant developing countries has increased from 22% in 1961 to 34% in 2012. The major drivers of this expansion are commercialized agricultural systems, notably soybean and cattle in Brazil (mostly for exports) and palm oil in South-East Asia, while in Africa it more likely that population growth and subsistence farming are more prominent drivers, at least until recently.

What are the consequences of these major shifts in land use? First and foremost, the radical shift in land use away from developed and land constrained countries towards more land-abundant countries has led to large scale destruction of natural ecosystems. Deforestation understandably the most attention this (Geist and Lambin, 2002, Hosonuma, et al., 2012), though non-forest ecosystems, such as South American and African savannah systems, are also rich in biodiversity. Brazil, for example, has achieved impressive success in curtailing the once rapid deforestation of the Amazon, but arguably at the expense of *cerrado*, only 2 percent of which is under environmental protection.[2]

A second implication is that land availability is obviously a strong predictor of comparative advantage in agricultural trade, and that with the ongoing globalization of agricultural trade we will see this trend towards land expansion increasing.[3] That said, the agricultural economic profession has arguably not been very successful at reaching agreement in projecting future land use, with global models in staunch disagreement on future trends (Schmitz, et al., 2014), and even relatively incapable of predicting historical trends, at least at the regional level (Baldos and Hertel, 2013). Schmitz, et al. (2014) report results from 6 different models that estimated common economic scenario but reached very divergent predicts of land expansion, ranging from a modest decline to increases of 400 million hectares. The FAO also predicts approximately a 400 million hectare expansion of crop land in developing countries, even with yield growth accounting for the bulk of future production increases (Bruinsma, 2012). Climate change scenarios add further uncertainty for estimates of the potential to expand land. Xiao and Ximing (2011), for example, find that climate change and population growth will cause reductions in arable land in Africa, South America, India and Europe, but increases in Russia, China and the US.

---

[2] According to the Nature Conservancy, the Cerrado is home to 935 species of birds and nearly 300 mammals, including endangered species, and more than 400 tree and shrub species that are unique to the region. See: http://www.nature.org/ourinitiatives/regions/southamerica/brazil/placesweprotect/cerrado.xml

[3] Moreover, climate change modellers have predicted that the adverse impacts of climate change will be tempered by greater trade.

Evidently, predicting land use in global models is extremely difficult (Hertel, 2011)[4]., and inherently limited in terms of understand context-specific institutional issues affecting land exploitation. Even relatively sophisticated economic models lack well specified parameters on the costs of land conversion, and substitution between land and land-saving inputs (Hertel, 2011). Moreover, many factors that influence land use are highly context specific, such as public policies on agricultural R&D, investments in road infrastructure, and conservation efforts; the various surprises of land expansion in the Amazonia and Cerrado regions of Brazil being a case in point.[5] More careful regional studies are therefore need. For example, in a recent study on sub-Saharan Africa, for example, Chamberlin, et al. (2014) demonstrate that estimates of unused potentially arable cropland (PAC) are very sensitive to assumptions. With no protection of forests and no insurmountable costs to land conversion, some 400 million hectares could be converted to agriculture. But with sizeable infrastructure costs, low agricultural prices and persistent yield gaps, these estimates can fall as low as 80 million hectares. Moreover, the vast bulk of these unused PAC resources are located in just a few countries, making local policies, investments and institutions highly influential in determining the future of land use in the region.

3. Patterns and trends in farm sizes

The trends in absolute farming area discussed in the previous section have important implications for the environment, but no direct relevance for human welfare. In contrast, farm sizes – or farm land per capita – are often a very strong predictor of income levels and poverty rates, and (most likely) of undernutrition. In this section we therefore look at patterns and trends in average farm sizes, primarily using census and survey-based estimates, though we also do some Hayami-Ruttan type decompositions to understand the role of per capita farm land evolution in production growth across regions.

In Table 3 we report trends in average farm sizes based on the most recent available evidence. The data mostly consist of agricultural censuses collected under the FAO's *World Programme for the Census of Agriculture*.[6] For countries with missing data we supplemented the census data with results from household surveys conducted by colleagues at The International Food Policy Research Institute (IFPRI) and Michigan State University. There are plenty of caveats with these data. First, mixing together survey and census based estimates is questionable, though we are careful to exclude situations in which there are very marked discrepancies (which is rare). Second, surveys and censuses differ in whether they report land owned or land cultivated. Third, there is insufficient data on distribution of land, so we omit to report it here. Fourth, surveys and censuses are conducted in the same years, so time trends are not strictly comparable.[7]

[4] Hertel (2011) nicely discussed the technical issues that constrain more effective modelling of land use: even relatively sophisticated economic models lack well specified parameters on the costs of land conversion, and substitution between land and land-saving inputs.

[5] In the case of the cerrado, this region had been scarcely been broached by Brazilian farmers despite centuries of colonial settlement until modern R&D solved the regions soil problems; surely a nuance outside the purview of global models. Likewise the sudden deceleration in the deforestation of the Amazon rainforest was surprising to many, not least insofar as the private sector played a significant role after significant NGO pressure.

[6] This programme is currently midway through its 2010 phase, so relatively few of the observations in the "2000s" column are very recent. Still, farm sizes change relatively slowly over time in most countries.

[7] Nevertheless these census and survey based data are likely much more accurate than AGROSTAT based estimates of farm land per worker In addition to the errors involved in estimating farm land (cultivated land plus permanent

Bearing these caveats in mind, Table 3 reports results for different regions and selected large countries with available data. Based on previous research (Eastwood, et al., 2010, Headey, et al., 2010, Headey, et al., 2011, Headey and Jayne, 2014), as well as standard economic theories of structural transformation (Lewis, 1954), we would certainly expect farm sizes to shrink at early stages of development, before rising again as the population employed in agriculture starts to decline in the wake of lower fertility rates and agricultural exits to nonfarm occupations. The exceptions to this stylized evolution of farm sizes over the course of development would be land abundant developing countries where extensive farming practices would likely be more profitable and labor-saving (Boserup, 1965); in these countries we would expect farm sizes to stay the same even with sustained population growth, although the introduction of certain technologies (e.g. machinery) could promote land expansion.

The results in Table 3 are consistent with these expectations, though the extent of these changes over time is often very striking. For example, following Headey and Jayne (2014) we split sub-Saharan Africa into a land abundant and a land constrained group (mostly the higher density Eastern African countries). In the land abundant group farm sizes essentially stay the same, consistent with Boserupian theory. In the land constrained group, however, farm sizes have declined by almost half in recent decades. In South Asia – a region even more land constrained that the South Asian counterparts – farm sizes declined by almost 60%, both in India and in the rest of South Asia. This rapid decline probably masks involuntary landlessness in South Asia (Headey, et al., 2011). In the rest of Asia the story is more complex, as expected. In China farm sizes declined from the 1980s to around 2003, but have been increasing ever since. Zhang, et al. (2011) shows that rural wages also started to increase in 2003, suggesting that China reached its Lewis turning point at this stage, whereby rising nonfarm wages sucked surplus labor out of agriculture. Hence farm sizes can be expected to further increase in China, subject to institutional reforms. In Indonesia the situation is more complex, with the bulk of the agricultural population residing on Java, which has very small farms, while outer islands are relatively land abundant with a dualistic structure of small farms and large plantations. The statistics in Table 3 appear to refer to farm households rather than firms and appear to show a decline in farm size up to 2003, although preliminary estimates from the 2013 census suggest that – like China – farm sizes are now increasing. Moreover, data from the Indonesia Bureau of Statistics suggest that plantation areas in Indonesia have increased by 220 percent over 1995-2013, or almost 5 million hectares (oil palm plantations alone grew by 5.2 million hectares).[8] Farm sizes in the Middle East and North Africa are larger on average than these other regions (but more variable), yet this region is obviously highly water constrained, and also still experiencing fairly rapid population growth. As a result farm sizes declined by roughly 30 percent over this period. In Egypt – easily the largest country in our sample – they declined by almost 50%.

The story for more commercialized agricultural economies is very different, of course. Although the previous section noted a decline in agricultural area in more developed economies, the decline in agricultural workers and landholders has been even more rapid, resulting in increases in farm sizes in Western Europe (41%), Canada (68%), and Australia (41%) and Argentina (52%). In Brazil farm sizes appear to have stayed roughly the same. In the United States they have increased modestly (7%), though Sumner (2014) makes note of the large number of "hobby

---

meadows and pastures) AGROSTAT data on agricultural employment is very sketchy. See Headey, et al. (2010) for some discussion.

[8] This is based on data reported at: http://www.bps.go.id/linkTabelStatis/view/id/1665

farms” that distort these statistics. Excluding these micro farms would imply much larger average farm sizes in the US and many other Westeran countries.

Table 3. Census and survey-based estimates of trends in average farm sizes

	1960s-1980s	2000s	Change (%)
Small farm developing economies			
Sub-Saharan Africa (SSA) (N=14)	2.9	1.9	-32%
--land abundant SSA (N=9)	3.0	2.9	-2.1%
--land constrained SSA (N=5)	2.3	1.2	-46.9%
Other South Asia (N=4)*	2.5	1.1	-56%
India	2.7	1.2	-57%
Other South-East Asia (N=4)*	1.6	4.2	158%
Indonesia	1.0	0.8	-20%
China	0.7	0.6	-17%
Middle East & North Africa (N=9)	7.6	5.4	-29%
Commercialized agricultural economies			
South Africa	965.6	288.3	-70%
Other South America (N=7)	97.3	89.7	-8%
Argentina	383.3	582.5	52%
Brazil	70.7	68.2	-3.6%
Western Europe (N=16)*	14.7	20.8	41%
Canada	187.5	315.0	68%
United States of America	157.6	169.3	7%
Australasia & New Zealand	1468.5	2070.3	41%

Sources: Data collected by Headey and Jayne (2014).

Notes: *these averages are pooled averages across countries (i.e. we sum all land holdings and divide by the number of farm households/owners). Pooling was preferred, but not possible for other regions because only average farm sizes, not number of households and total landholdings, was reported.

Sumner (2013) also argues that farm sizes are not a good predictor of welfare in more developed countries, since high value agriculture tends to delink farm size from farm revenue. This issue seems less pertinent in developing country settings where farm sizes very closely associated with rural household income/expenditure and poverty status. This association is remarkably strong in both the cross-country data in Table 3 and in household survey-based studies. The data in Table 3 show that, by the World Bank’s definition of income status, no low or lower middle income country has an average farm size in excess of 6 hectares per capita. For South Asia Headey, et al. (2011) review the associations between farm sizes and poverty. In Pakistan Anwar et al. (2004) the rural poverty rate among the landless is 55%, among nonfarm workers it is 48% and among small farmers it is 32%, while among farmers with more than 1 hectare it is zero. In Bangladesh the rural poverty rate among essentially landless farm laborers is 73% versus 40% for self-employed farmers, 49% for nonfarm laborers and 42% for self-employed non-farmers (Hossain 2004). In Nepal largely landless agricultural wage earners also had the highest poverty rate (53.8%), rather distantly followed by self-employed in agriculture (32.9%), self-employment in manufacturing (31.2%) and nonfarm wage earners (28.8%) (CBS 2005). In India 41.8% of the poor report agricultural labor as their primary occupation, followed by self-employment in agriculture (26.7%) and much lower shares for other labor categories (Eswaran et al. 2009). It is also likely that adjustment for irrigation and soil quality would only strengthen these relationships.

A series of country case studies on land constraints and agricultural development in Africa reached very similar conclusions (Jayne, et al., 2014). Like the literature on the inverse productivity relationship, these studies show that smaller farm typically obtain somewhat higher yields and higher revenue per hectare, but not to an extent sufficient to compensate for smaller farm sizes. For example, using village level data for Ethiopia, Headey, et al. (2014) find that land constrained villages use more inputs per hectare, get higher cereal yields and higher value per hectare, and more net revenue per hectare. But even so a reduction of 1 hectare predicts a decline in income of around 60 US dollars per year – a sizeable amount of money in such a poor setting.

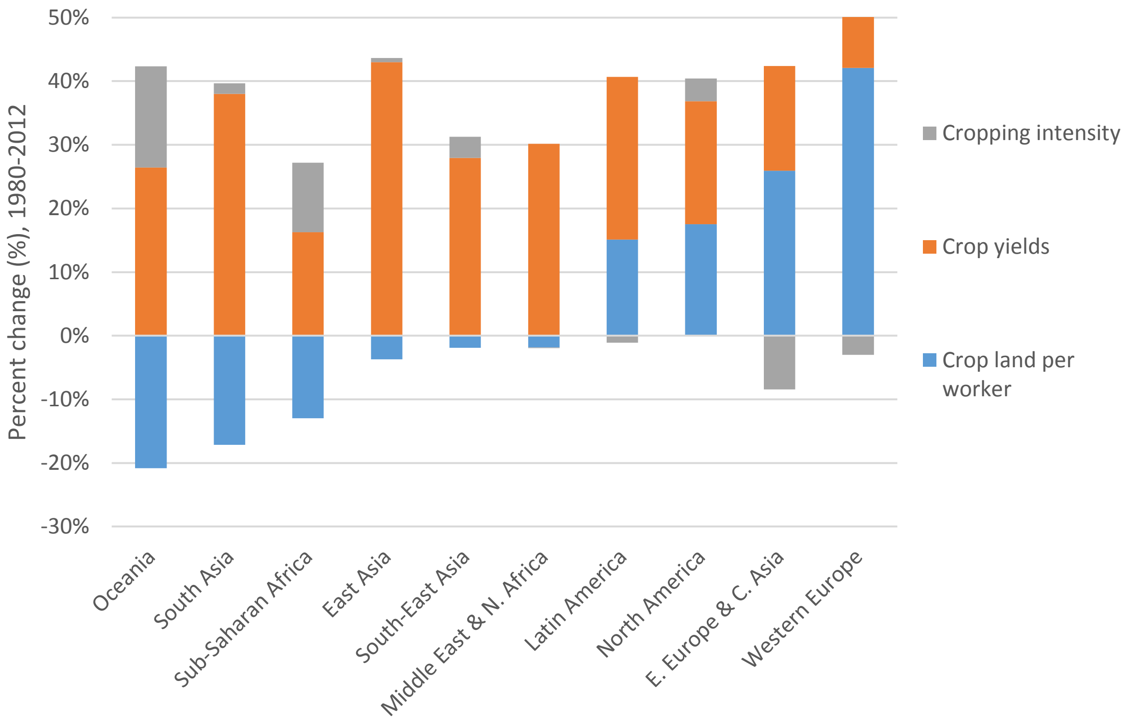
Of course, it is difficult to say whether these relationships are causal – unobservable household or village characteristics could influence both farm sizes and income – but in sub-Saharan Africa there are legitimate reasons to be concerned about the impacts of land constraints on agricultural development. Whilst South Asia has struggled with similar problems, the rapid yield gains – and spillover effects on rural wages and nonfarm economic growth – substantially compensated for shrinking land endowments (Headey, et al., 2011). And while India, in particular, arguably has something of a “backlog” of too many people still toiling on small and relatively unproductive farms, rural population growth is slowing down in South Asia (for example, India’s rural population is expected to peak in 2022), and nonfarm economic opportunities are expanding rapidly. In sub-Saharan Africa the picture is very different. Though land constraints are not quite as severe, water and soil constraints are much more severe, suggesting yield potential is less in Africa. Moreover, rural populations will continue to growth well into the middle of the 21st century so even countries with moderate land constraints could well be highly constrained in a generation or two.

Figure 5 presents some admittedly crude evidence in support of these concerns.[9] Here we decompose total crop production value per agricultural worker from 1980 to 2012 into three sources of growth: crop land per worker, crop yields (value per hectare) and crop intensity (ratio of area harvested to area used at least once in 5 years).[10] Figure 5 suggests that land per capita has declined more rapidly in South Asia than in sub-Saharan Africa, but that yield growth has been over twice as large in South Asia. Moreover, relatively to other developing regions, Africa has relied more heavily on increased cropping intensity. However, this increased cropping intensity in Africa has not coincided with significant investments in irrigation or much acceleration in chemical or non-chemical fertilizer use. The gradual depletion of nutrients – or nutrient mining – in African soils seems of particular concern (Stoorvogel, et al., 1993, Drechsel,

[9] An obvious limitation of the decomposition in Figure 5 is that we ignore livestock production.
[10] The identify underlying this decomposition is: $Y/N = L/N * H/L * Y/H$ where is Y is crop value, N is the agricultural workforce, L is land area used at least once in the last 5 years, H is area harvested in a given year.

et al., 2001, Henao and Baanante, 2006, Tittonell, et al., 2008, Jayne and Rashid, 2013, Jayne, et al., 2014).

Figure 5. Sources of growth in crop production per agricultural worker, 1980-2012



Source: Author's estimates from FAO (2014) data.

What can be done about declining farm sizes?

Boserup (1965) and her followers rightly emphasized that farming systems adapt and evolve in response to mounting land constraints; by intensifying production through more application of inputs per hectare, and – in some contexts - through switching to higher value products. The limitations of Boserup's theory for agricultural development strategies were acknowledged several decades ago by (Pingali, et al., 1987), in particular: the theory describes a long run endogenous adaptation to land constraints under relatively moderate rates of population growth. Population growth rates in the second half of the 20th century were unprecedented for poor countries, essentially due to the importation of Western science, particularly vaccinations. These population pressures reduces land availability in the space of a generation or two. But while these pressures do create a Boserupian demand for more intensive farm practices, the endogenous supply response to this demand has been insufficient. As is well known, the Asian Green Revolution provided an exogenous source of intensification that allowed the region to circumvent the dire Malthusian predictions of the early post-colonial period.

But the most successful Asian countries essentially treated these population pressures as a broader economic transformation problem rather than an agricultural problem. Much underemphasized by agricultural economists, for example, is the important role of fertility reductions in densely populated Asian countries. China, Vietnam, Bangladesh, India and Indonesia have all successfully reduced fertility rates above and beyond what would have been expected from contemporaneous growth in income, albeit through a mixture of both family planning and education investments, particularly for girls (World-Bank, 2005, Pörtner, et al., 2012). In contrast, African countries have had very little success in reducing fertility. For example, despite tremendous land pressures Rwanda still has a fertility rate of 4.6 children, whereas Bangladeshi women have only 2.3 (roughly replacement levels). In recent work on this neglected issue, Headey and Jayne (2014) find that land pressures lead to reduced demand for children in Africa (i.e. lower desired fertility rates) but not to actualized declines in fertility. This suggests a large unmet demand for contraception in Africa.

The second dimension of this transformation problems is nonfarm employment, both in urban areas and the rural nonfarm economy. Here there are diverse views, with some authors suggesting that agricultural growth provides the platform for nonfarm job creation (Johnston and Kilby, 1975, Mellor, 1995), whilst others emphasize industrial policies (Wade, 1989, Rodrik, 1995, Foster and Rosenzweig, 2004), and both likely agreeing that infrastructural investments are catalytic in this regard. Again, Africa has struggled to follow the labor-intensive industrialization path so characteristic of Asian development, and there are ongoing debates about whether this approach is even feasible in Africa given its apparent comparative in resource-intensive sectors (McMillan and Rodrik, 2011, Dinh and Clarke, 2012, Gollin, et al., 2013).

Table 4 illustrates just how better African countries need to do on this front by comparing some economic transformation indicators in Ethiopia (a country with considerable land and water constraints in much of the highlands) and Bangladesh (a country with very severe land constraints, but abundant water resources). Although agroecologically very different to each other, Ethiopia and Bangladesh both have a history of food insecurity and famine, and widespread cognizance of the importance of land pressures for economic development. Moreover, unlike many African countries, Ethiopia is considered a recent success story on multiple fronts, including the achievement of rapid growth in cereal yields, a massive expansion of rural roads and recent success in reducing fertility rates. But Table 4 suggests that even this regional success story falls a long way behind Bangladesh, despite the many positive trends in Ethiopia. In truth, only Ethiopia's achievements in yield growth are comparable to Bangladesh's experience. On all fronts the country still has a long way to go.[11] In other land constrained African countries basic transformation trends are generally less encouraging. Fertility rates have actually been rising in Kenya and are remarkably high in Uganda (where family planning policies have long been rejected by the Museveni government). And lack of job creation outside of agriculture is essentially a pervasive problem throughout the region, especially in the formal sector. However, recent studies of job creation issues in sub-Saharan Africa, such as Filmer and Fox (2014), tend to be overoptimistic as far as land constrained East African countries are concerned.[12] Certainly opportunities for land expansion in these countries are quite limited.

[11] Moreover, cereal growth in Ethiopia has been widely questioned.
[12] Filmer and Fox (2014) write: "If land is available and crop area is still expanding, increased farm size need not displace labor, especially where the cost of capital to invest in mechanization is high… The current context is one of high global food prices, huge potential for growth in area and yield." In many populous East African countries opportunities for land expansion are very limited, and while yield gaps are large, opportunities for intensive

Table 4. Economic transformation indicators in Ethiopia and Bangladesh

	Ethiopia			Bangladesh		
	1994	2012	*Percent change (%)*	1994	2012	*Change (%)*
Fertility rate (births per woman)	7.0	4.8	*-32%*	6.2	2.2	*-65%*
Cereal yields (kg per hectare)	974	1,961	*101%*	1,937	4,357	*125%*
Agriculture (% of GDP)	55.7%	48.0%	*-14%*	25.6%	17.7%	*-31%*
Electrified households (%)	8.0%	23.2%	*188%*	20.2%	53.6%	*165%*
Net secondary school enrollment (%)	7.5%	30.2%	303%	15.7%	47.7%	204%

Source: World Bank (2014).

4. Conclusions

One normally only thinks of agricultural land use as evolving relatively slowly. However, in recent decades global land use has changed drastically. Farm land has declined in the rich world – even as average farm sizes have expanded), stayed constant in land constrained developing countries, and expanded with astonishing speed in the land abundant parts of South America, South-East Asia and sub-Saharan Africa. The global agricultural landscape in 2015 looks very different to the landscape of 25 years ago, let alone 50 years.

These changes in land use are the complex outcomes of resource endowments (land water availability), demographic forces (especially rapid population growth in the least developed countries), economic incentives (including expanding opportunity for trade), and institutional factors (especially government policies towards agriculture, infrastructure and environmental conservation). Many of the most significant and transformative events in agricultural land use over the last half century proved difficult if not impossible to predict, not least the complex expansion of agricultural land in South America and South-East Asia. Others were predictable – such as shrinking farm sizes in South Asia and sub-Saharan Africa – but often ignored by both researchers and policymakers.

Looking forward, our confidence in the predictions of global land use models should therefore be tempered. These models can also be improved upon and augmented with other kinds of research, including more refined spatial analyses, as well as microeconomic and institutional analyses of land use decisions, land markets and land policies. Given the fundamentally important role that land endowments play in both agricultural development and broader economic transformation, it

irrigation-based farming are limited. Likewise, long run food price projections typically predict a secular decline, not an increase.

is perhaps surprising that land issues do not feature more prominently in the contemporary scope of economics research.

References

Anderson, K., Masters, W. A., 2009. Distortions to agricultural incentives in Africa. World Bank, Washington DC.

Angelsen, A., Kaimowitz, D., 2003. Agricultural Technologies and Tropical Deforestation. CABI Publishing in association with Center for International Forestry Research (CIFOR), Oxon, UK and New York, USA.

Baldos, U., Hertel, T. W., 2013. Looking back to move forward on model validation: Insights from a global model of agricultural land use, *Environmental Research Letters.* **8**.

Binswanger, H. P., McIntire, J., 1987. Behavioral and Material Determinants of Production Relations in Land-Abundant Tropical Agriculture, *Economic Development and Cultural Change.* **36**, 73-99.

Binswanger, H. P., Rosenzweig, M., 1986. Behavioural and Material Determinants of Production Relations in Agriculture, *Behavioural and Material Determinants of Production Relations in Agriculture.* **22**, 503-539.

Boserup, E., 1965. *Conditions of agricultural growth*. Aldine Publications, Chicago.

Brink, A. B., Eva, H. D., 2009. Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach, *Applied Geography.* **29**, 501-512.

Bruinsma, J., 2012. The resources outlook: by how much do land, water and crop yields need to increase by 2050?, in P. Conforti ed., *Looking ahead in world food and agriculture: Perspectives to 2050*. Food and Agriculture Organisation, Rome.

Byerlee, D., Stevenson, J., Villoria, N., 2014. Does intensification slow crop land expansion or encourage deforestation?, *Global Food Security.* **3**, 92-98.

Chamberlin, J., Jayne, T. S., Headey, D., 2014. Scarcity amidst abundance? Reassessing the potential for cropland expansion in Africa, *Food Policy.* **48**, 51-65.

Dinh, H. T., Clarke, G. R. G., 2012. Performance of Manufacturing Firms in Africa. The World Bank, Washington DC.

Drechsel, P., Kunze, D., de Vries, F. P., 2001. Soil Nutrient Depletion and Population Growth in Sub-Saharan Africa: A Malthusian Nexus?, *Population & Environment.* **22**, 411-423.

Eastwood, R., Lipton, M., Newell, A., 2010. Farm size, in P. Pingali and R. Evenson eds., *Handbook of Agricultural Economics*. Academic Press, Burlington.

FAO, 2014. FAOSTAT. Food and Agriculture Organization, Rome.

Filmer, D., Fox, L., 2014. Employment in Sub-Saharan Africa, available.

Foster, A., Rosenzweig, M., 2004. Agricultural Productivity Growth, Rural Economic Diversity, and Economic Reforms: India, 1970-2000, *Economic Development and Cultural Change.* **52**, 509-542.

Geist, H. J., Lambin, E. F., 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation: Tropical forests are disappearing as the result of many pressures, both local and regional, acting in various combinations in different geographical locations, *BioScience.* **52**, 143-150.

Gollin, D., Jedwab, R., Vollrath, D., 2013. Urbanization with and without Structural Transformation. Working paper. Department of Economics, George Washington University. Available.

Headey, D., Bezemer, D., Hazell, P. B., 2010. Agricultural Employment Trends in Asia and Africa: Too Fast or Too Slow?, *World Bank Research Observer.* **25**, 57-89.

Headey, D., Dereje, M., Taffesse, A. S., 2014. Land constraints and agricultural intensification in Ethiopia: A village-level analysis of high-potential areas, *Food Policy.* **48**, 129-141.

Headey, D., Fan, S., 2008. Anatomy of a crisis: the causes and consequences of surging food prices, *Agricultural Economics.* **39**, 375–391.

Headey, D., Hazell, P. B., Nin-Pratt, A., 2011. Is South Asian agriculture overcrowded? An empirical inquiry. Background paper for the World Bank report, "More and better jobs in South Asia". International Food Policy Research Institute (IFPRI), Washington DC. Available.

Headey, D. D., Jayne, T. S., 2014. Adaptation to land constraints: Is Africa different?, *Food Policy.* **48**, 18-33.

Henao, J., Baanante, C. A., 2006. *Agricultural production and soil nutrient mining in Africa : implications for resource conservation and policy development*. IFDC-An International Center for Soil Fertility and Agricultural Development, Muscle Shoals, AL.

Hertel, T. W., 2011. The Global Supply and Demand for Land in 2050: A Perfect Storm?, *American Journal of Agricultural Economics.* **93**, 259-275.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R., S. De Fries, Brockhaus, M., Verchot, L., Angelsen, A., Romijn, E., 2012. An assessment of deforestation and forest degradation drivers in developing countries, *Environmental Research Letters.* **7**, 1-12.

Jayne, T. S., Chamberlin, J., Headey, D. D., 2014. Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis, *Food Policy.* **48**, 1-17.

Jayne, T. S., Rashid, S., 2013. Input subsidy programs in sub-Saharan Africa: a synthesis of recent evidence, *Agricultural Economics.* **online version**.

Johnston, B. F., Kilby, P., 1975. *Agriculture and structural transformation: Economic strategies in late-developing countries*. Oxford University Press, London.

Kaminski, J., Headey, D., Bernard, T., 2011. The Burkinabè Cotton Story 1992-2007: Sustainable Success or Sub-Saharan Mirage?, *World Development.* **39**, 1460-1475.

Klein Goldewijk, K., Ramankutty, N., 2004. Land cover change over the last three centuries due to human activities: The availability of new global data sets, *GeoJournal.* **61**, 335-344.

Lewis, A. W., 1954. Economic Development with Unlimited Supplies of Labour, *The Manchester School.* **28**, 139-191.

McMillan, M., Rodrik, D., 2011. Globalization, Structural Change and Productivity Growth. Working Paper 17143. Cambridge, MA. Available at http://ideas.repec.org/p/nbr/nberwo/17143.html.

Mellor, J. W., 1995. Agriculture on the Road to Industrialization. John Hopkins University Press, Baltimore.

Meyfroidt, P., Rudel, T. K., Lambin, E. F., 2010. Forest transitions, trade, and the global displacement of land use, *Proceedings of the National Academy of Sciences.* **107**, 20917-20922.

Pingali, P., Bigot, Y., Binswanger, H., 1987. *Agricultural Mechanisation and the Evolution of Farming Systems in Sub-Saharan Africa*. John Hopkins University and the World Bank, Washington DC.

Pörtner, C. C., Beegle, K., Christiaensen, L., 2012. Family Planning and Fertility: Estimating Program Effects Using Cross-Sectional Data. Policy Research Working Paper 5812. The World Bank, Washington DC. Available.

Ramankutty, N., Foley, J. A., Olejniczak, N. J., 2002. People on the Land: Changes in Global Population and Croplands during the 20th Century, *AMBIO: A Journal of the Human Environment.* **31**, 251-257.

Rodrik, D., 1995. Getting Interventions Right: How South Korea and Taiwan Grew Rich, *NBER Working Paper No. 4964*.

Ruthenberg, H., 1980. Farming System in the Tropics. Clarendon Press, Oxford, U.K.

Ruttan, V., Hayami, Y., 1984. Toward a Theory of Induced Institutional Innovation, *Journal of Development Studies.* **20**, 203-223.

Schmitz, C., van Meijl, H., Kyle, P., Nelson, G. C., Fujimori, S., Gurgel, A., Havlik, P., Heyhoe, E., d'Croz, D. M., Popp, A., Sands, R., Tabeau, A., van der Mensbrugghe, D., von Lampe, M., Wise, M., Blanc, E., Hasegawa, T., Kavallari, A., Valin, H., 2014. Land-use change trajectories up to 2050: insights from a global agro-economic model comparison, *Agricultural Economics.* **45**, 69-84.

Schoneveld, G. C., 2014. The geographic and sectoral patterns of large-scale farmland investments in sub-Saharan Africa, *Food Policy.* **48**, 34-50.

Sitko, N. J., Jayne, T. S., 2014. Structural transformation or elite land capture? The growth of "emergent" farmers in Zambia, *Food Policy.* **48**, 194-202.

Stoorvogel, J. J., Smaling, E. M. A., Janssen, B. H., 1993. Calculating Soil Nutrient Balances in Africa at Different Scales .1. Supra-National Scale, *Fertilizer Research.* **35**, 227-235.

Sumner, D. A., 2014. American Farms Keep Growing: Size, Productivity, and Policy, *Journal of Economic Perspectives.* **28**, 147-66.

Swinnen, J., 2001. Transition from Collective Farms to Individual Tenures in Central and Eastern Europe, in A. De Janvry, G. Gordillo, J.-P. Platteau and E. Sadoulet eds., *Land Reform Revisited: Access to Land, Rural Poverty and Public Action*. Oxford University Press, Oxford.

The-Economist, 2010. Brazilian agriculture: The miracle of the cerrado, *The Economist*, London.

Tittonell, P., Vanlauwe, B., Corbeels, M., Giller, K. E., 2008. Yield gaps, nutrient use efficiencies and response to fertilisers by maize across heterogeneous smallholder farms of western Kenya, *Plant and Soil.* **313**, 19-37.

Wade, R., 1989. What Can Economies Learn from East Asian Success?, *Annals of the American Academy of Political Science.* **505**, 68-79.

World-Bank, 2005. Maintaining Momentum to 2015? An impact evaluation of interventions to improve maternal and child health and nutrition outcomes in Bangladesh, available.

World-Bank, 2014. World Development Indicators Online. The World Bank, Washington, DC.

Xiao, Z., Ximing, C., 2011. Climate change impacts on global agricultural land availability, *Environmental Research Letters.* **6**, 014014.

Zhang, X., Yang, J., Wang, S., 2011. China has reached the Lewis turning point, *China Economic Review.* **22**, 542-554.