Changing diets in a changing world: assessing the impact of urbanisation on agriculture

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December, 2015

The authors are grateful to Ruerd Ruben for his insightful comments. Lindsay Shutes is grateful to the Centre for Agroecology, Water and Resilience at Coventry University, UK, for hosting her as a visiting scholar. All errors and omissions remain however, the responsibility of the authors. We acknowledge financial support from the Ministry of Economic Affairs as part of the Knowledge Base programme on Global Food Security (KB-22-003-001 ; KB-22-001-002).

Introduction

By 2050, two thirds of the world's population is projected to live in urban areas; rising from 54% in 2014 (United Nations,2014). Coupled with increasing economic growth, the trend for increasingly wealthy urban consumers is expected to have important implications for the pattern of food demand and consequently, agricultural production. Asia and Africa are home to the largest growing urban centres (medium sized cities of less than 1 million inhabitants) and China and India will contribute more than one third of the expected growth in global urban population between 2014 and 2050 (United Nations,2014). An analysis of the impact of urbanisation on agriculture is largely absent from the literature yet it is likely to have a significant impact as urban consumers consume more high-value processed products and the underlying rural-urban migration has consequences for the agricultural labour supply.

The projected increase in the share of people living in urban areas in China, India, and Ghana, between 2010 and 2030 is shown in Figure 1 for two variants (IIASA, 2015). Under the medium urbanisation projection variant (the darker lines of each country), the share of the population in urban areas rises from 47% in China and 51% in Ghana, to 61% and 63% respectively. India is set to experience a higher rate of urbanisation as the share of people living in urban areas increases from 30% to 42% over the same period. The higher variant projects that 68% of the population will live in urban areas in China and Ghana by 2030 and 49% in India by 2030.

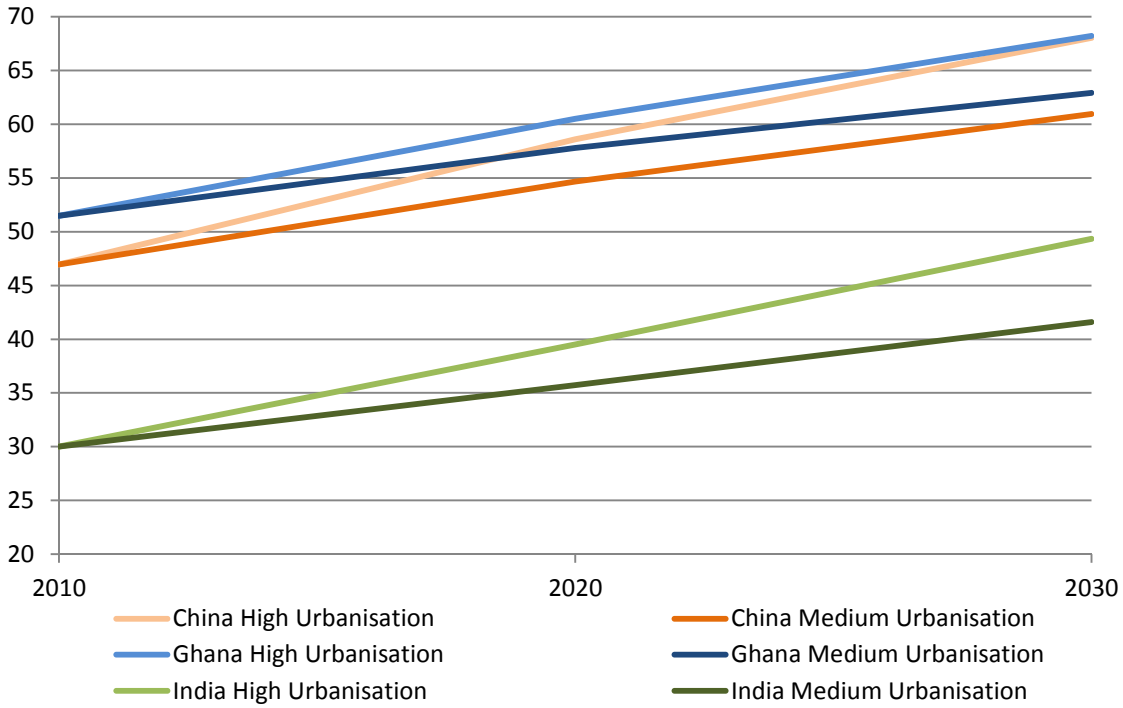

Figure 1 Percentage share of total population living in urban areas 2010-2030 (IIASA, 2015)

Effects of urbanisation on dietary transition & agriculture

Using household survey data, Huang & Bouis (2001)found that urban living in China and Taiwan brought with it changes in tastes that significantly impacted food demand. Using time series data for nine Asian countries, Huang & David (1993) found that urbanization in high income countries led to a

reduction in the demand for cereals grains but had no impact on cereal demand in low income countries. The demand for rice and coarse grains fell due to urbanization whilst the demand for wheat increased showing that dietary transition occurs both between staples and non-staples and between different staples. Rae (1998) examines this hypothesis for the demand for animal-derived products in six East Asian countries; finding that urbanization uniformly leads to higher levels of consumption of animal-derived products.

The pathways through which urbanisation affects agriculture is three-fold: the lower share of income spent on food by wealthier urban consumers, the different composition of urban consumers' diets compared to rural consumers' diets, and changes to the agriculture labour supply arising from large scale migration to urban areas.

Capturing the impact of urbanisation

Structural change that affects both the consumption and production sides of an economy, such as urbanisation, requires an assessment framework that covers the whole economy and captures the dual nature of citizens as both consumers of food and suppliers of labour to the agricultural sector. Computable General Equilibrium (CGE) modelling provides such a framework as it includes the complete flow of goods from production to consumption and imports and exports, and income and expenditure, from factor remuneration to household income and spending on goods and services.

The Modular Applied GeNeral Equilibrium Tool (MAGNET) is a recursive dynamic, multi-sector, multi-region CGE model (Woltjer et al., 2013). It is developed from the standard GTAP model (Hertel 1997) and has at its core, an input-output system that links industries in a value added chain from primary goods, over continuously higher stages of intermediate processing, to the final assembly of goods and services for consumption. Goods at any stage of production can be traded between regions. MAGNET is calibrated to version 9 of the GTAP database (Narayanan et al. (Eds), 2015), which contains detailed bilateral trade, transport and protection data (import tariffs, export subsidies and subsidies to agricultural outputs, inputs and factor payments) characterizing economic linkages among regions, together with detailed country input-output databases accounting for domestic inter-sectoral linkages. All monetary values in the data are in million U.S. Dollars and the base year selected for version 9 is 2007 which is updated in MAGNET to 2010 using macroeconomic and agricultural yield data. The 140 regions in the GTAP database are aggregated to 33 regions for simulation purposes (Table 1), with a focus in the results on three key regions: Ghana, China and India which are selected for their rapidly urbanising nature and regional coverage. Starting from 57 sectors identified in the GTAP database the MAGNET database identifies more sectoral detail for agriculture (like fertilizer), crop-livestock interactions (like feed which can be produced from by-products of raw commodity processing) and biofuel sectors which may compete with food consumption. In this study we include 33 sectors producing 36 commodities (Annex 1 lists the model sectors). The sectoral aggregation covers agricultural products, industrial products, utilities and services and retains separate identification of key products including: staple crops -- rice, grains, and wheat; high value crops -- vegetables, fruits and nuts; and processed foods – meat, meat products, vegetable oils and fats and dairy products.

The MAGNET model goes beyond the standard GTAP model in four ways relevant to the question of the impact of urbanisation on the agricultural sector. First, in its agricultural sector, MAGNET includes

imperfectly substitutable types of land, a land use allocation structure, land supply functions and substitution between various animal feed components. This representation of land as a key input to agriculture captures the effect of change demands for crops on agriculture through the pressure on land. Second, MAGNET allows for observed differences in agricultural and non-agricultural wages by introducing imperfect labour and capital mobility between the two sectors which allows for changes in agricultural wages and returns due to faster growth in the labour supply in urban areas. Third, the inclusion of the MAGNET nutrition module (Rutten et al., 2013) shows how urbanisation affects the calories per person that are consumed in urban and rural areas and from when the calories are sourced; both in terms of the composition of the diet and domestic or imported products. Finally, and most importantly for this study, MAGNET includes a new household module (Kuiper and Shutes, 2014), which is an extension of the MyGTAP model (Minor and Walmsley, 2013; Walmsley and Minor, 2013).

The household module replaces the regional household, which collects income, saves and allocates income to the private household and government, in the standard GTAP model, with explicit income flows to households and government. Households receive income from the supply of factor services, remittances, foreign income and transfers and save a share of their income. The government receives income from tax revenues and aid payments and (dis)saves a share of its income which forms the internal balance. Separating the household and government accounts in this way introduces a direct link between changes in sources of income and change in household and government income; enriching country level analysis.

Furthermore, the single private household is replaced with multiple household types in key regions and crucially introduces a distinction between urban and rural households. In the current model, 9 household types are included in Ghana covering 5 urban households: Accra, Urban Coastal, Urban Forest, Urban South Savannah and Urban North Savannah and 4 rural households: Rural Coastal, Rural Forest, Rural South Savannah and Rural North Savannah; an Urban and Rural household in China and 5 rural and 5 urban households in India grouped by income quantile (<10%, 10-30%, 30-70% and >90%). These extensions yield a global model, not unlike many single country models, which can be used for multiple household analysis including distributional issues such as the impact of urbanisation on the agricultural sector. Specifically, adding multiple household groups introduces distinct patterns of factor income and consumption that determine the impact of changes in urbanisation on food demand and the agricultural sector.

In addition, a greater number of factor types is included which strengthens the link between economic activity and household income (Kuiper et al., 2015). The unskilled labour category is disaggregated for Ghana into six types covering self-employed labour in each agro-ecological zone, elementary labour and non-agricultural unskilled labour. Labour is divided into rural and urban skilled and unskilled categories in India; while the standard skilled and unskilled categories are retained for China due to a lack of detail in the underlying national Social Accounting Matrix.

Consumption patterns

The diets of urban consumers differ from those of rural consumers . Firstly, the share of income spent on food falls as incomes rise and we observe that the percentage share of income spent on food by urban and rural households in Ghana is 60% and 71% respectively, 34% and 38% in India and 23% and 40% in China[1]. Secondly, urban consumers spend a lower proportion of their food budget on staple good such as wheat, rice and other grains. Finally, urban consumers spend a higher proportion of their food expenditure on high value products such as fruit and vegetables, meat and dairy, and other processed food. Figure 2 shows the structure of urban and rural dietary spending and shows that these characteristics broadly hold for Ghana, India and China.

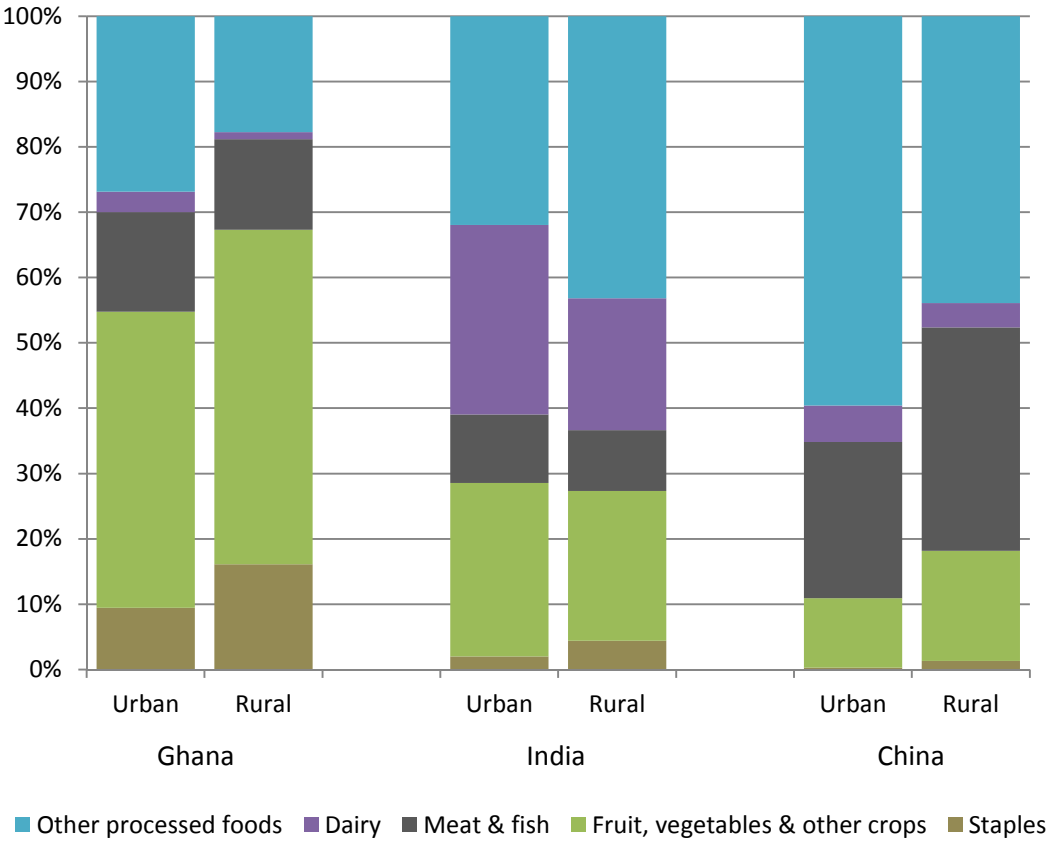

Figure 2 Spending on food categories by urban and rural households

The initial picture of the Chinese, Ghanaian and Indian economies as captured in the GTAP and MAGNET databases show the differences between urban and rural households. However, it is the behavioural equations of the MAGNET model that determine how household consumption, and therefore the demand for agricultural products progresses over time. Consumption is represented in MAGNET by a Constant Difference of Elasticities (CDE) demand system. The main advantage of the CDE is its nonhomotheticity, increasing its capability to capture the impact of large income changes on consumption patterns. Although commodities are net substitutes, large income effects can make commodities gross complements (Burfisher, 2011). Although the CDE has desirable properties for assessing large income changes we need to employ two additional calibration procedures to ensure that consumption behaviour is accurately represented. First, the share of each additional dollar spent

[1] Authors' calculations from the MAGNET database.

on food products falls as incomes rise. This calibration follows economic estimates of the relationship between GDP and food consumption. Second, the function is calibrated to ensure that households demand a level of consumption that corresponds to an appropriate level of caloric intake.

Labour supply

Scenarios

Urbanisation has been introduced to CGE models in different ways. Doresh & Thurlow (2011) allows differential in the urban/rural wage to generate internal migration in Ethiopia which changes the labour supply growth rates over time in the two regions. Conversely, Zhou et al. (2015) introduce urbanisation through an exogenous increase in the urban labour supply and a corresponding decrease in the rural labour supply in an examination of the impact of urbanisation on energy consumption in China.

We follow the approach of Zhou et al.: introducing an exogenous increase in the urban population and accompanying labour force, and an accompanying decrease in the rural population and labour supply. This approach allows urban and rural wages to develop endogenously in response to the changes in the labour supply. Furthermore, the urban and rural population growth rates are a combination of growth in the national population and movement between the two regions. In this analysis, we capture both elements by targeting urban and rural growth rates that satisfy the projected national population growth rate and the projected urbanisation share. In the high urbanisation scenario, the national population growth rate is maintained and only the projected share of the urban population is increased, to isolate the impact of urbanisation on agriculture.

We examine the impact of urbanisation on agriculture through two scenarios based on the projections in Figure 1: a baseline scenario and a high urbanisation scenario. The baseline scenario follows the Shared Socio-Economic Pathway 2 ("Middle of the Road") in which urbanisation follows current trends and developing countries follow the experiences of more developed countries (IIASA, 2015). Population growth, GDP growth and yield changes similarly follow 'Middle of the Road' projections. Implementing a baseline allows us to evaluate the impact of high urbanisation rates in the world of 2030, rather than smaller short run changes compared to the world of today. The high urbanisation scenario follows the same economic projections as the baseline but with higher rates of urbanisation taken from Shared Socio-Economic Pathway 1.

The projected shares of the population in urban areas and growth rates in GDP, total population and urban and rural population under the two scenarios are given in Table 1.

		Urban share		Population/labour supply growth		
	Scenario	2010	2030	Total	Urban	Rural
China	Baseline	51	63	3	34	-24
	High urbanisation	51	68	3	49	-38
Ghana	Baseline	30	42	47	80	13
	High urbanisation	30	49	47	95	-4
India	Baseline	47	61	25	73	4
	High urbanisation	47	68	25	105	-10

Table 1 Projected growth in GDP and population 2010-2030 and urban share in 2030
Source: authors' calculations from SSP database (IIASA, 2015)

The low total population growth rate in China means that almost all of the growth in urban areas and corresponding decline in rural areas in both scenarios is due to the process of urbanisation and internal migration. In contrast, the high population growth rate in Ghana and India means that both urban and rural areas grow in the baseline scenario; albeit with urban areas growing at more than 6 times in Ghana and 18 times in India, the rate of rural areas. The higher rate of urbanisation in the second scenario means that the growth in urban areas in Ghana and India is brought about by migration from the rural area that outstrips natural population growth and the population of the rural area declines.

Results

The results presented in this section are given as the percentage difference between the two scenarios; thereby distilling the effect of the increased urbanisation rate. Higher rural-urban migration increases both the number of people and the supply of labour in urban areas. This translates into higher incomes as shown in Figure 3.

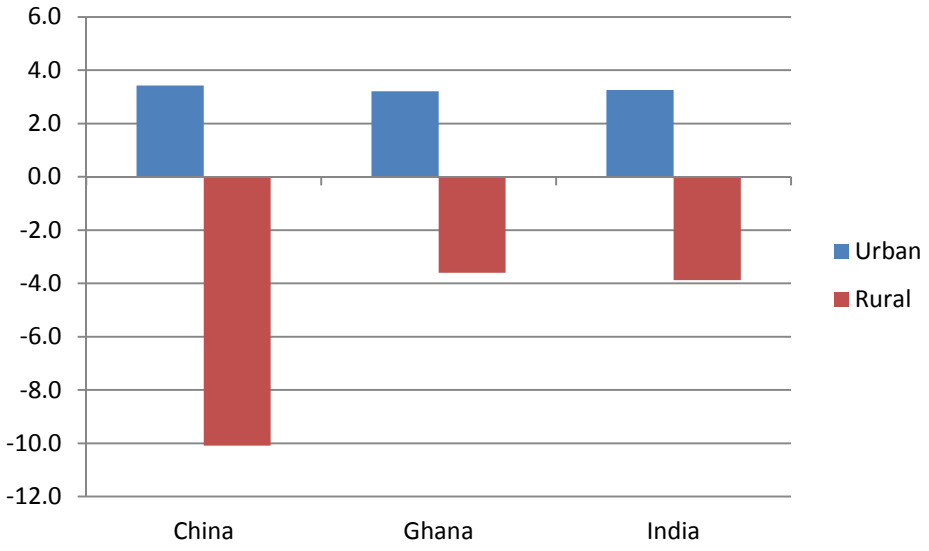

Figure 3 Change in household income by urban and rural grouping in 2030 due to higher urbanisation (percentage difference from baseline)

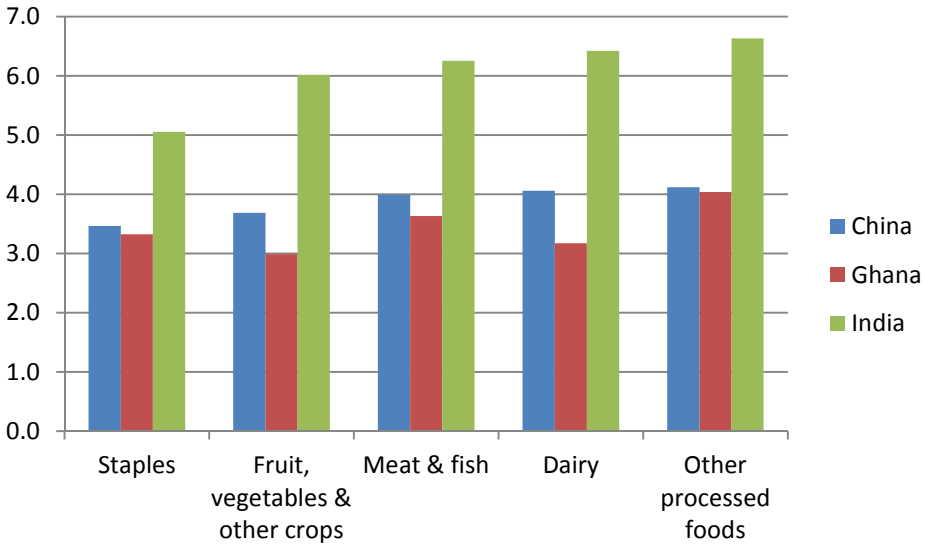

Figure 4 Change in demand for food types by urban households in 2030 due to higher urbanisation (percentage difference from baseline)

Higher incomes in urban areas boost demand for food in all categories, with the largest increases seen in the higher value products of meat and fish, dairy and processed foods. The largest increase is observed in India, followed by China and Ghana. The decline in incomes in the rural area lead to a reduction in consumption across all food product with the largest reduction in staples and fruit, vegetables and other crops. In contrast to the changes in consumption in the urban area, the largest changes in the rural area are observed in China, followed by India and Ghana.

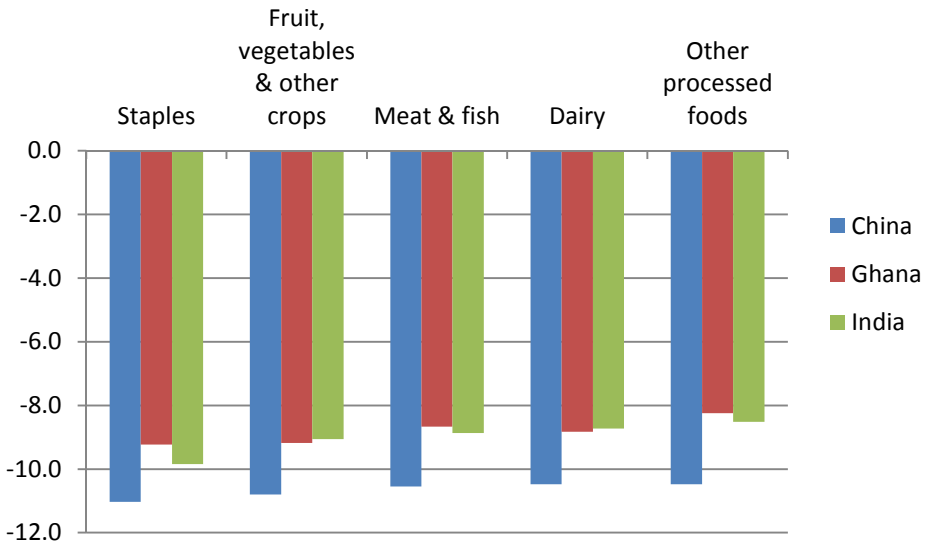

Figure 5 Change in demand for food types by rural households in 2030 due to urbanisation (percentage difference from baseline)

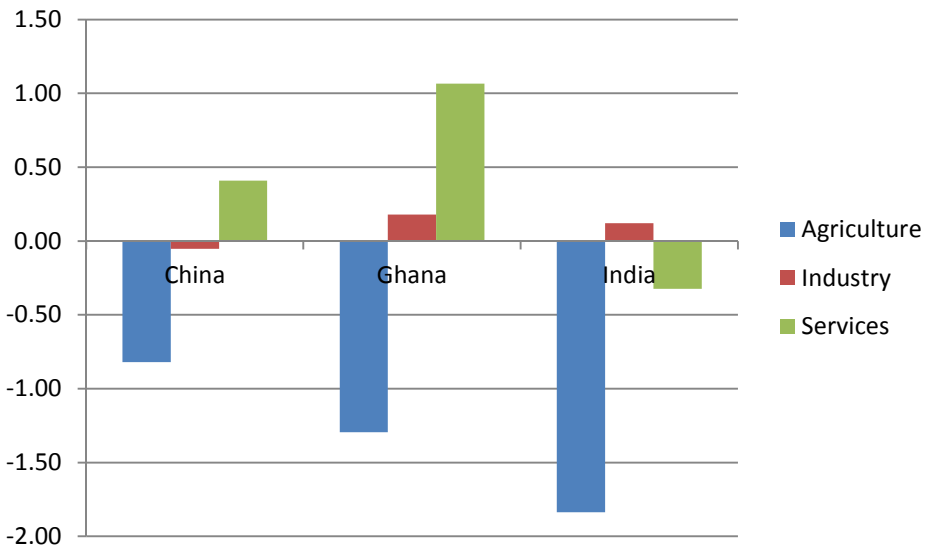

Figure 6 Change in contribution of agriculture, industry and services to total output in 2030 due to urbanisation (percentage difference from baseline)

The shifts in consumption and changes in the supply of labour arising from urbanisation lead to a contraction in the agricultural sector. This structural change is accompanied by changes to industry and the service sector which are different for each of the three countries. India sees a sharp decline in the agricultural sector accompanied with an expansion in the industrial sector, whereas the decline in the agricultural sector in China is partnered a slight contraction to the industrial sector and an expansion of the service sector. Finally, both the industrial and service sectors in Ghana expand as agriculture contracts. This is in line with recent observations that *'migration to urban areas has led to a structural transformation away from subsistence agriculture that has boosted Ghana's economy, with an increase in industry and service jobs from 38 to 59 percent between 1992 and 2010.'*[2]

Conclusions

The analysis presented in this paper examines the impact on agriculture that arises due to urbanisation. We capture the difference in urban diets due to income, lower consumption of staples and higher consumption of high-value products such as fruits and vegetables and meat and dairy.

This approach does however have some limitations. Urbanisation is introduced as an exogenous shock to the three economies which implies that urbanisation is itself a driver of structural change. However, urbanisation may be an indicator of structural change, rather than a driver if workers are moving between regions in response to better job opportunities and higher wages and/or a declining agricultural sector. In this case, development is driving urbanisation and an equally valid question would be, what is the impact of changes in the agricultural sector on urbanisation?

An interesting area for future work is the impact of greater eating outside the home among urban households, for example, in restaurants or from street food vendors.

[2] http://www.worldbank.org/en/news/opinion/2015/05/14/rising-through-cities-in-ghana-the-time-for-action-is-now-to-fully-benefit-from-the-gains-of-urbanization

Furthermore, we omit the likely increase in remittances from urban to rural areas which would reduce the disparity in incomes between the two regions and dampen the observed effects.

Finally, urbanisation is assumed to lead to the growth of all urban households equally and a uniform decline in all rural households. Further detail on the dynamics of urbanisation, such as the most likely types of workers to migrate, would improve the analysis and lead to more nuanced results.

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Table 1 Regional aggregation

MAGNET model regions

Code	Description
can	Canada
USA	North America
mex	Mexico
CAM	Central America
bra	Brazil
RSM	Rest of South America
NAF	Northern Africa
gha	Ghana
WAF	Western Africa
eth	Ethiopia
ken	Kenya
uga	Uganda
EAF	Eastern Africa
RSF	Rest of Southern Africa
zaf	South Africa
EU16	Western EU
EU12	Central EU
RWE	Rest of Western Europe
RCE	Rest of Central Europe
tur	Turkey
UKR	Ukraine Region
CAS	Central Asia
RUR	Russia Region
ME	Middle East
ind	India
RSA	Rest of South Asia
kor	Korea
chn	China
CHR	China Region
SEA	Southern Asia
idn	Indonesia
jpn	Japan
OCE	Oceanaia

Table 2 Sectoral aggregation

Primary sectors	pdr	Paddy rice
	wht	Wheat
	gro	Cereal grains not elsewhere classified
	hort	Vegetables, fruit, nuts
	osd	Oil seeds
	c_b	Sugar cane, sugar beet
	crops	Other crops
	oagr	Other agriculture
	Ctl	Cattle,sheep,goats,horses
	oap	Animal products nec
	rmk	Raw milk
	Fsh	Fishing
	Frs	Forestry
Processed food	cmt	Meat: cattle,sheep,goats,horse
	omt	Meat products not elsewhere classified
	vol	Vegetable oils and fats
	mil	Dairy products
	pcr	Processed rice
	sugar	Sugar and molasses
	cvol	Crude vegetable oil
	pfd	Processed food incl. beverage and tobacco
Animal feed	feed	Animal feed
Fertilizers	fert_n	fertilizer nutrient n
	fert_p	fertilizer nutrient p
	fert_k	fertilizer nutrient k
Energy	coa	Coal
	c_oil	Crude oil
	gas	Gas
	gdt	Gas manufacture, distribution
	petro	Petroleum and coal products (excl first generation biofuels)
	Ely	Electricity
	biog	Biogasoline
	biod	Biodiesel
Low tech industry	lowind	Other low tech industry
High tech industry	highind	Other high tech industry
Services	svcs	Services