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Agricultural labour productivity and food prices: fundamental development impacts and indicators

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Abstract

In the last few years high and unstable food and agricultural commodity prices and concerns about population growth, increasing per capita food demands and environmental constraints have pushed agriculture and food production up national and international political, policy and research agendas. Drawing on both theory and empirical evidence, this paper argues that fundamental impacts of agricultural productivity and food price changes on development and poverty reduction are often overlooked in current debates. This is exacerbated by a lack of relevant and accessible indicators for monitoring agricultural productivity and real food prices. Two relatively simple and widely applicable sets of indicators are proposed for policy use in monitoring agricultural productivity and food price changes. Historical series of these indices are estimated for selected countries, regions and the world, and their strengths, weaknesses and potential value are discussed in the context of the need for better sustainable agricultural development and food security indicators in any post 2015 successors to the current MDGs.

Acknowledgements

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Agricultural productivity and food prices: fundamental development impacts and indicators

Andrew Dorward,

1. Introduction

Recent years have seen increasing average food prices, severe food price shocks (in 2008 and 2010/11), and increasing concerns about the impacts of food prices shocks, high food prices and food price volatility on poor and food insecure people. This paper reviews historical changes in staple food prices (in terms of international grain prices) and then uses basic microeconomic development theory to consider agricultural productivity and food price impacts on and roles in development and poverty reduction. This provides a foundation for subsequent design of indicators for monitoring agricultural productivity change and food price changes relative to the real incomes of poor people. Historical series of two sets of indicators are estimated for selected countries, regions and the world, and their strengths, weaknesses and potential value discussed. The paper concludes with a discussion of the challenges posed by this analysis in the context of growing threats to global food availability and the relevance of the proposed indicators to debates on new international development goals to follow the Millennium Development Goals after 2015.

2. Long term changes in staple food prices

(Dorward, 2012b) shows that changes in staple food prices reflect changes in the opportunity cost of food consumption and production in terms of real income and substitution effects for consumers and cost, substitution and income effects for producers. Monetary food prices should therefore be compared with other price series when looking at price changes: staple food prices should be deflated by consumer price indices and income comparators when examining food price changes for consumers, and deflated by other agricultural product prices and by input prices when examining food price changes for producers, as shown in figure 1 [1].

[1] International grain prices are summarised using the World Bank Development Prospects Group 'cereals' price index. This hides considerable diversity in shorter term price fluctuations between maize, wheat and rice, but shows well the broad patterns which are common to all the main grains.

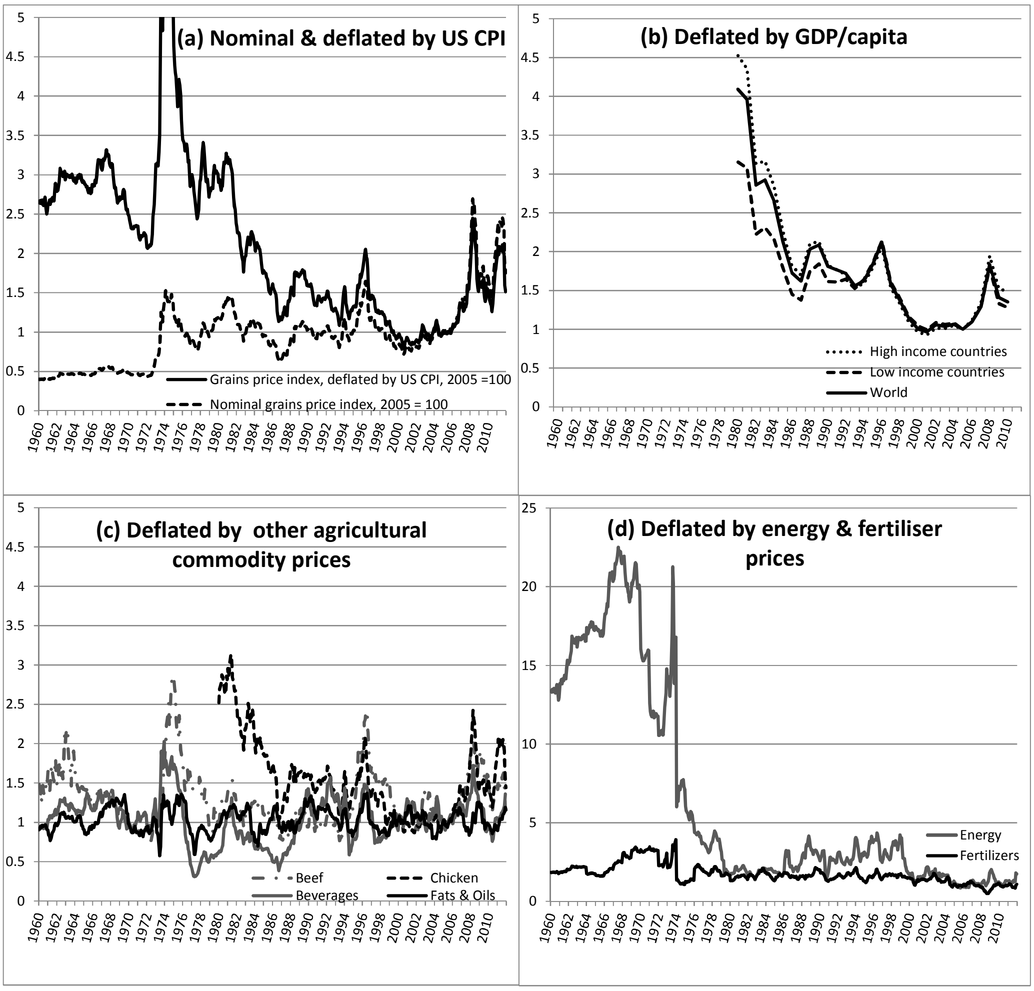

Figure 1 Indexed grain prices 1960-2011 (2005 = 100)

Sources: (World Bank, 2012), (Bureau of Labor Statistics, 2012)

For measures of price changes more relevant to grain producers' decisions (though not necessarily to their relative incomes), Figure 1(c) shows international grain prices deflated by the prices of other agricultural commodities that farmers might produce (although this does not allow for the effects of tariffs, subsidies and technical change on different commodities' relative profitability). This analysis shows no clear secular change in grain prices relative to other agricultural commodities. Figure 1(d), however, shows a dramatic fall in the price of grains relative to energy during and following the 1970s oil crisis and from 2002. A similar pattern, but considerably dampened, is observed for the price of grains prices relative to fertilisers. It should be noted that the larger scale in figure 1(d) may appear to suggest that from 1980 grain prices have fallen much less relative to fertiliser prices than to GDP per capita or US CPI (in figures 1(a) and (b). This is only partly true: grain prices relative to fertilisers also follow a different pattern.

In summary then, nominal grain prices have risen dramatically since the 1960s, but in real terms

- they have fallen substantially relative to the prices of other goods and services consumed by richer people
- they have fallen substantially relative to the incomes of rich people

- there are no readily available indicators of changes more relevant to poor consumers, but price falls are less than for rich consumers (see below and (Dorward, 2011))
- there are no clear changes against prices of other agricultural commodities
- they have fallen dramatically against oil prices and less dramatically against the prices of fertilisers

These observations raise two questions: why do we observe these patterns, and what is their significance for understanding the long term developmental impacts of food price changes?

3. Longer term impacts of changes in food prices

We structure discussion of the two questions about the causes and effects of long term patterns of food price change by considering three factors affecting and affected by long term food price changes: area expansion, technical and institutional change, and structural change.

3.1. Area expansion

A major long run change affecting food prices has been the historical expansion of the area planted to food crops. Table 1 shows how figures for areas under cereals and arable production have changed since 1961 and 2000. Although the accuracy and reliability of some of these figures may be questioned (for example there is a sudden large jump in reported areas under cereals in upper middle income countries in 1992), there appears to be a consistent longer term and more recent pattern of change increasing area under cereals and wider arable production in lower income countries (with increases in cereal areas in low income countries partly at the expense of other crops' share of land) and a slowly declining area under cereals and wider arable production in higher income countries. Rates of growth (decline) are lower (higher) for low (high) income countries in the period from 2000 (although this may not pick up responses to higher 2008 prices). However continued expansion of cultivated areas is problematic in most parts of the world due to (a) environmental and sustainability problems with cultivation in marginal and forested land and (b) shortages of other fertile and well watered land (for example (Hazell and Wood, 2008), (Foresight, 2011)), although there is potential for substantial expansion of cultivated areas in parts of sub Saharan Africa (for example (Binswanger-Mkhize and Morris, 2009)), despite substantial challenges (Binswanger-Mkhize and Morris, 2009; Hazell and Wood, 2008).

Table 1. Changes in yields and areas from 1961 and 2000

	Period	High income (OECD)	Upper middle income	Lower middle income	Low income	World
Cereal land	1961-2009	-0.08%	0.77%	0.79%	1.63%	0.65%
Arable land	1961-2008	-0.09%	1.77%	0.65%	0.95%	0.60%
Cereal land	2000-2009	-0.28%	0.49%	0.53%	2.43%	0.55%
Arable land	2000-2008	-0.46%	-0.12%	0.25%	1.22%	-0.02%
Cereal yield	1961-2009	1.90%	2.30%	2.04%	0.96%	1.85%
	2000-2009	1.43%	1.73%	1.60%	1.18%	1.38%

Source: Author calculations from (World Bank, 2011)

3.2. Technical and institutional change

The major long run change affecting food prices considered in neo-classical economic theory is technical change, the change in production functions as a result of technical innovation and new technology. This is a major driver of global increases in cereals yields and, with increases in cultivated areas discussed above, of historical production increases. Technical change may be embodied in new forms of physical and natural capital (for example machinery and seeds). Another form of very long run change is the development of new institutions – rules and structures governing social, political and economic interactions (North, 1990). Theories of induced technical and institutional change relate technology, institutions, resource endowments and culture together, with changes in each driving interactive change in others (Ruttan and Hayami, 1984).

This analysis suggests that high food prices raise the incentives for governments and private companies to invest more in agricultural research, to develop such technologies, and implement policies and services that will promote the adoption of such technologies. It is widely argued that low food prices (relative to other commodities) caused many governments and the international community to reduce their investment in agricultural research, and this is cited by some authors as one of the causes of the slow-down in agricultural productivity growth from the mid 1990s (for example (Piesse and Thirtle, 2009)). (Timmer, 2010) argues that there is a roughly thirty year cycle of world food crises, as falling food prices depress government and private investment in agricultural research, until the rate of growth in demand overtakes supply, triggering a crisis, which kick starts renewed investment in research until prices fall again: far sighted governments should therefore invest more consistently to prevent food crises in the future. However global trade means that low food prices are a global public good[2] and hence investment in agricultural research should be globally coordinated[3]. This recognises that governments have an interest in preventing food price crises. However this interest arises not just from the consideration of the negative 'short and medium term' impacts discussed by (Dorward, 2012b): there is a much more fundamental, long term reason for governments concerned about their citizens welfare to seek long term falls in food prices: in order to promote structural change and economic growth.

3.3. Structural change

Governments and other agencies seeking to promote poverty reduction and economic growth and development should have a particular interest in lowering food prices relative to income as these are an important determinant of wider economic growth. This is illustrated in figure 2, which shows how agricultural labour productivity plays a foundational role within wider economic development processes.

[2] In the long run low food prices are non-excludable and non-rival benefits from government investment in agricultural research, and they also arise as an externality from commercial research investments in excludable technologies. In the short term they arise as externalities from producers' and traders' decisions to produce and sell food.

[3] Potential limits on continued expansion of high external input and energy dependent technologies from global environmental problems associated with them are discussed later, but reductions in these 'public bads' are another form of global public good from investments in agricultural technology development.

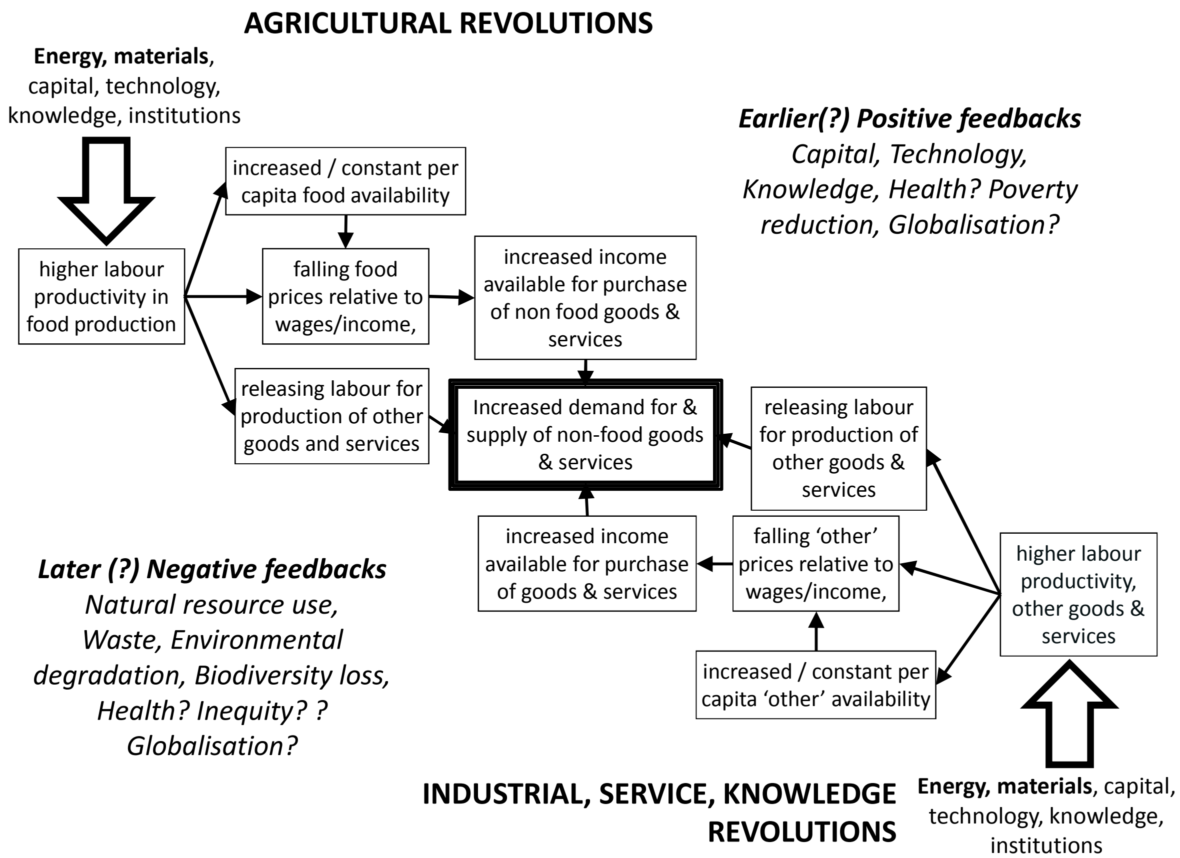

Figure 2 Food, energy and development processes and challenges

Following a long standing literature on the role of agricultural development in wider development processes (for example (Johnston and Mellor, 1961; Mellor, 1995; Timmer, 1988)) and in line with more recent empirical work (Christiaensen et al., 2011), the top left corner of figure 2 shows how agricultural revolutions that raise agricultural labour productivity in poor agrarian economies can play multiple foundational roles in wider development processes, as increased production per worker leads to increasing food availability per worker. This then (a) lowers the cost (and hence price) of food relative to agricultural worker incomes, (b) this raises agricultural workers' budget surpluses after food expenditures and hence increases their real incomes, (c) this stimulates demand for non-food goods and services and (d) simultaneously releases agricultural labour from food production to production of other goods and services (as fewer workers are needed to produce the food that society requires). Agricultural labour productivity growth in poor agrarian economies thus simultaneously raises productivity of poor countries' and poor people's abundant and critical resource (agricultural labour), raises their real incomes, and stimulates both supply and demand of non-food goods and services (in the centre of the figure). This simultaneous creation of supply and demand is critical to but often lacking in changes stimulated by development interventions.

The figure also shows, starting from the lower right corner, how industrial, service and knowledge revolutions have built on the basic, initial increase in supply and demand for non-food goods and services to lower the labour costs of their production. In this these revolutions are performing the same function as the earlier agricultural revolution. However agriculture's relative importance, and the potential benefits from increased agricultural labour productivity then fall, as food production's shares of labour use and expenditure fall. This is matched by increasing importance of industrial, service and knowledge revolutions in raising the productivity of increasing amounts of labour involved in the production of non-food goods and services, which are responsible for an increasing share of consumer expenditures.

A number of points should be noted about this analysis.

- First, falling food prices relative to incomes are an essential part of this process and have been a characteristic of all wealthy and developed economies, and indeed of all wealthy groups within rich and poor societies (see figure 1(b)). This may be considered an 'economic truth' that arises from a fundamental 'accounting identity' (Schelling, 1995)[4]
- Second, broad based increases in the productivity of labour applied to staple food production on small farms offer an important but challenging and transitional means of widespread, pro-poor growth in poor agrarian economies[5]. They lead to increases in productivity and in returns to large amounts of relatively unproductive resources (land and labour) that are important in both the national economy and in the livelihoods of poor people. As noted earlier, labour productivity changes simultaneously stimulate (a) a push of labour into the supply of non-food goods and services and (b) an increase in income available for the purchase of these goods and services, which later pulls labour out of agriculture. Increases in capital intensive productivity outside the smallholder sector (e.g. in large scale mechanised commercial agriculture or mining) do not deliver these coordinated stimuli in poor agrarian economies. Of course policy may seek to reproduce this, using taxes and subsidies to transfer income from owners of capital and smaller numbers of skilled workers to poor rural people (as for example with social protection policies in Brazil). However this presents significant political economy and governance challenges and requires a large, highly productive and rapidly growing large scale capital intensive sector that can support these very large transfers. It also misses an important potential growth opportunity by not simultaneously raising the productivity of poor people's labour – unless rural labour can be quickly absorbed into rapidly growing labour intensive manufacturing. Consideration of the relative merits of large scale and small sale agricultural development must therefore take these issues into consideration as well as differences in productivity, productivity growth and size between the large and small scale agriculture sectors[6]. Such approaches may be appropriate in emerging and middle income economies, but despite difficulties with smallholder development are unlikely to provide efficient and rapid routes to poverty reduction and broad based growth in many poor agrarian economies.[7]

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[4] I am indebted to Dirk Bezemer for drawing this to my attention.

[5] The importance of 'labour demanding technical change' has long been recognised in agricultural economics literature – for example (Lipton and Longhurst, 1989).

[6] (Christiaensen et al., 2011) provide a useful empirical examination of these issues.

[7] The arguments in this paragraph are also relevant to explanations of how some small trading countries (such as Singapore and Hong Kong) and some oil rich countries have achieved rapid growth without developing their own agricultural sectors: these countries have normally started with very small poor rural populations and have relied on agricultural development in other countries for low price food imports.

- Third, there are major challenges in achieving welfare and developmental benefits from low food prices without undermining incentives for farmers to invest in new technologies and increased production. The ‘food price tightrope’ needed to tread this path is particularly difficult in the early stages of growth in poor agrarian economies, and governments have used a variety of output, input, and technology and investment support policies to promote increased food crop production and productivity without ‘high’ prices. Some of these policies have been remarkably successful, while others have been disastrous failures (for example (Dorward et al., 2004)).
- Fourth, both the agricultural and the industrial, service and knowledge revolutions have been based on fossil fuels replacing bioenergy (and hence solar energy) sources for tillage and nitrogen fixation, on increased use of material inputs, on new technologies (often associated with fossil fuel and material inputs), on new knowledge, and on accumulation and investment of private and public capital (in varying mixes of technology and equipment; knowledge; fossil fuel extraction and use; transport and communications systems; and institutions). However there is growing evidence and concern about environmental limits on continued high dependence on fossil fuels and materials, about rising prices of energy and material inputs, and about increasing competition between food and energy production (for example (Foley et al., 2011; Foresight, 2011; Godfray et al., 2010a; Naylor, 2011)). Furthermore, while various positive feedbacks have supported development processes in the past (for example capital accumulation; economies of scope in technology development and knowledge generation and application; improved health and human capital; and positive aspects of globalisation) some of these may be reaching their limits while negative feedbacks are growing in importance. These include limits to natural resource availability (for example water and land), loss of natural resources due to over-exploitation and degradation, reduced productivity due to waste and pollution (climate change perhaps the most serious and egregious example), associated biodiversity loss, health problems (increasing incidence of obesity and related diseases alongside continued undernutrition - ((McLellan, 2002; Prentice, 2006)), and negative impacts of globalisation and inequity.
- Fifth, and drawing together previous points, limits and threats to increased labour productivity in food production are threats not only to the ability of the world to feed its growing population and to provide that population with high levels of material consumption and prosperity, but to the fundamental ‘economic truth’ or accounting identity on which development is based. This raises serious questions about alternative less material visions of prosperity based, for example, on greater sharing of services and less material consumption (for example (Jackson, 2009)) and about the extent to which non-industrial forms of agricultural (such as agroforestry or agro-ecological, conservation or organic farming) can support developed societies if they require higher labour input per unit output to maintain or raise per hectare yields[8]. These issues raise fundamental and important questions not only about global food and agricultural systems and the prospects of poor agrarian

[8] Such approaches are often criticised for having high labour requirements, but this is by no means universal (for example herbicide use in conservation farming reduces weeding labour requirements), but while information on yields and labour use per hectare are commonly discussed, this is not the case for labour productivity (for example (de Schutter, 2011) while the IAASTD Synthesis report ((IAASTD, 2009)) frequently mentions agricultural, farm, crop, animal, water, energy, input and land productivity and efficiency, but there is no reference to labour productivity, apart from an indirect mention of ill health effects on productivity).

economies: these issues are fundamentally important to aspirations about standards and modes of living in developed economies too, and about structures of society and economic activity (for example (Lang, 2010; Van Der Ploeg, 2010; Weis, 2010)).

This analysis, along with the widely documented equitability and efficiency of smallholder farming in many poor rural economies (for example (Hazell et al., 2010)), highlights the importance of smallholder farming in addressing both global and local agricultural and food system challenges[9]. More fundamentally, it shows that long run technical and structural change underpin economic development and 'developed' societies: food prices, agricultural worker productivity, and global threats to supply / demand balances are fundamental long term development issues. In addition to their critical importance for food security, health and physical and mental development for poorer children and adults, they affect the global economy and the welfare of rich as well as poor economies, nations and people. As global public goods, research and policy for high rural labour productivity in sustainable and resilient agricultural and food systems need much greater attention in international policy than they have had in the past - they should for example be a core part of any successor to the Millennium Development Goals after 2015 (Waage et al., 2010). Their inclusion in such a scheme, however, needs coordination around policy goals and targets, and targets need indicators. In the following sections we therefore consider possible indicators for use in national and international policy. We consider first indicators of agricultural productivity change and then of food price changes.

Before moving on, however, it is important to note that similar arguments may be made about energy costs and prices as about food costs and prices: low energy costs and prices are also fundamental to modern economies and standards and modes of living (depending to some extent on climates). This exacerbates the agricultural labour productivity and food price threats to prosperity and development discussed here – unless low cost renewable energy sources and systems can be rapidly developed and deployed.

4. Developing indicators of agricultural productivity change

We now consider possible indicators for use in national and international policy concerned with promoting agricultural productivity that supports the fundamental development processes and addresses the threats identified in the previous section. This is an issue that is of particular importance given growing debate about what could and should follow the current MDGs after 2015. We first identify the desirable features that such indicators should have if they are to be useful in supporting national and international target setting and monitoring. Experience with the MDGs is useful here (see (Waage et al., 2010)). We identify 4 broad criteria

1. Indicators must first be relevant to policy goals and targets, demanding not only that they should have a sound theoretical basis and discourage 'goal displacement' difficulties, they should also be intuitively meaningful and appealing to policy makers and the wider public and promote 'joined up' and holistic thinking within and across sectors.

[9] Poulton (*pers. comm.*) notes that under this analysis if a small country achieves agricultural growth when there are high prices in world markets then this will delay the transition out of agriculture, possibly leading to a delayed industrialisation. While this depends upon success in solving the food price tightrope problem and in promoting labour demanding technical change, it could present opportunities for smallholders in Africa given expected continuation of higher global food prices.

2. Indicators should also be consistently applicable over time and across different countries and different circumstances in order to allow comparison across countries and regions and analysis of change within countries and regions.
3. Timely and sufficiently comprehensive and reliable and accurate data for these indicators should be either available or potentially available (ideally the former), at reasonable cost for national, regional and global calculations
4. Ideally such data should already be available for historical analysis and comparisons.

Earlier sections of this paper have established that staple food prices and agricultural labour force productivity[10] are critical for people's welfare and long term economic growth and structural change. Value added in the agricultural sector divided by size of the agricultural labour force should then be an appropriate measure of agricultural productivity. Difficulties in choice of price measures to account for changing prices across different agricultural commodities can be addressed by measuring value added in terms of cereal equivalents, by dividing value added by the price of cereals. This sidesteps the pricing problem (provided that equivalent measures are used for current prices of cereals and in value added measures) and simultaneously recognises the fundamental importance of staple food prices relative to all economies, rich and poor, as well as to poor people.

We propose, therefore, as a core indicator of agricultural development and its wider contribution to the economies of which it is a part, an indicator we term the Cereal Equivalent Productivity of Agricultural Labour (or CEPAL) where

$$\text{CEPAL} = \frac{\text{Agricultural Value Added}}{\text{Agricultural Workers} * \text{Cereal Prices}}$$

Operationalisation of this indicator requires definition and sourcing of each of the variables. This is not, in principle, a difficulty for 'Agriculture Value Added' or for 'Agricultural Workers', for which data are routinely available at country level in the World Bank's World Development Indicators (World Bank, 2011) [11]. There are more difficulties with cereal prices. Questions arise about the relative desirability and availability of international prices and of domestic prices, about the weighting of different cereals in aggregate prices, and for some countries about the inclusion of non-cereal staples. An argument can be made for using international prices if these differ from domestic prices as a result of government interventions, as under these circumstances international prices may be a better measure of true efficiency prices. However this will not be the case if prices differ as a result of natural barriers to trade. In either case weighting of different cereals' prices should take account of their relative importance in local consumption, and ideally one would move from prices of staples to prices per kcal from all staples, including root crops, weighted by their calorific share in food consumption. There are, however, practical difficulties in obtaining data on local prices and consumption shares. FAOSTAT has domestic producer prices from 1991, but data series are not

[10] It should be noted here that productivity per hour worked is not critical for the processes of structural change and development discussed earlier, but the average productivity of all labour in the agricultural sector, whether fully, or partially employed, or indeed unemployed.

[11] The WDI provides 'Agriculture Value Added' and 'Agricultural Value Added per Worker at constant 2000 US$', from which Agricultural Workers can be calculated. FAOSTAT also provides data on 'Total economically active population in Agriculture'. The two sources have very similar data, though the WDI data appears to have fewer inconsistencies. Data quality is an issue, which we discuss later.

complete and appear to contain some discrepancies. No readily available and comprehensive source was identified with yearly data by country on staple consumption shares (FAOSTAT has information on production shares, but this will not be appropriate for countries with large grain imports or exports).

To provide some test of the indicator, data series for CEPAL were constructed first using international grain prices from the World Bank (World Bank, 2012) and then (for countries but not regions) using domestic producer prices from FAOSTAT, weighted by production shares (FAO, 2011).

Indicators may be presented using absolute estimates (in kg of cereal equivalent per worker) or indexed, the former allowing comparison between countries and regions and the latter allowing analysis of changes in productivity within and across countries and regions.

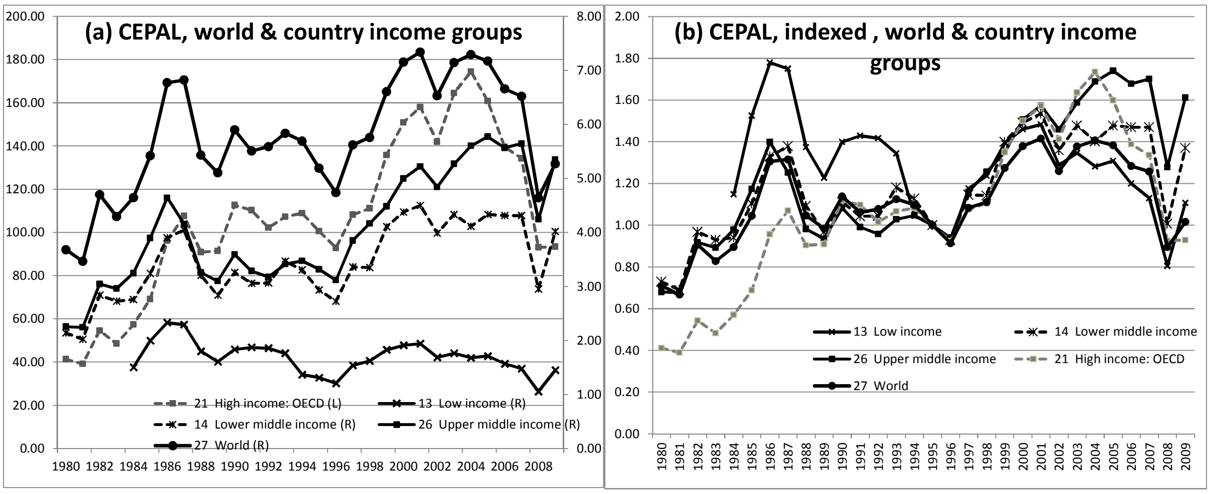

Figure 3 CEPAL (tonnes grain equivalent / worker) by country income group

For (a) OECD high income group is scaled on the left hand axis, other income groups on the right

Source: calculated using World Bank international grain prices and weights

Figure 3 shows estimates of CEPAL by country income group, first with raw values and then indexed. There are striking differences between raw values of labour productivity between the high income group and other groups (requiring raw data for high income countries to be scaled separately on the left hand axis in figure 3(a)).Cereal equivalent labour productivity rises steadily from low to high income groups, and has generally risen from 1980 to 2010, except for low income countries - but the extent of the rise varies between income groups and falls during periods of high cereal prices[12]. A fall in CEPAL from 2004 in high income countries (also reflected in the global CEPAL estimate) may be explained by changes in agricultural support policies in OECD countries (Poulton, *pers. comm.*).

Figures A1 to A3, in Annex A, show estimates of CEPAL and indexed CEPAL for selected countries in Asia, Sub Saharan Africa and Latin America, and also compare estimates using international grain

[12] Although grain prices rises lead to a fall in productivity measured by CEPAL (due to a fall in the relative price of non-cereal agricultural produce), the relationship between falling grain prices and rising measures of productivity not linear because very low grain prices lead to very low value addition in cereal production, and even losses. Given cereals' large share of global agricultural production this depresses agricultural productivity measured by CEPAL. Low prices may also lead to reduction in production and higher prices in subsequent years as farmers switch out of cereal production and/or reduce input use in cereal production.

prices with those using weighted domestic producer prices from FAOSTAT. The data set constructed with domestic prices is less complete and shows less variability, but otherwise yields broadly similar similar patterns as obtained with international prices. CEPAL therefore appears to be a valid and useful indicator for supporting national and international target setting and monitoring, although further work is needed to develop and improve domestic price data. Standardisation in the definition of and data collection on agricultural workers may also need investigation and improvement – agricultural labour productivity may be underestimated in low income countries, for example, where rural people may be classified as agricultural workers but obtain substantial proportions of their incomes from non-farm activities (Haggblade et al., 2010; Reardon, 1998).

Our earlier consideration of agricultural productivity's role in stimulating economic growth and structural change also highlighted threats to agricultural labour productivity from constraints or costs in using fossil fuels in agriculture and from limits to further expansion of agricultural land[13]. It is therefore also appropriate to develop targets for monitoring land and energy productivity in agriculture. Similar indicators to CEPAL can be constructed by replacing agricultural labour by land and fertiliser use in the CEPAL formula. We therefore define Cereal Equivalent Land Yield (CELY) as

$$\text{CELY} = \frac{\text{Agricultural Value Added}}{\text{Agricultural land * Cereal Prices}}$$

and Cereal Equivalent Productivity of Inorganic Fertiliser (CEPIF) [14] as

$$\text{CEPIF} = \frac{\text{Agricultural Value Added}}{\text{Inorganic fertiliser use * Cereal Prices}}$$

Figure 4 presents estimates of these two indicators by country income groups. Estimates for selected countries are presented in annex B.

[13] The other critical productivity challenge that requires an equivalent indicator is perhaps water productivity.

[14] No direct measure of energy or fossil fuel use in agriculture is available. However manufacture of inorganic nitrogenous fertiliser is a major user of energy so fertiliser us is proposed as a proxy for energy use, using World Development Indicators data on inorganic fertiliser use. No estimates of the relative importance of fertilisers in agricultural energy demands in different regions or economies could be located, but examination of specific studies (Cruse et al., 2010; Hill et al., 2006; Pimentel, 2009) and the dramatic growth in fertiliser use in low and middle income countries suggest that fertiliser use accounts for a major part of energy and fossil fuel requirements in low and middle income countries. In high income countries greater use of machinery means fertiliser use is likely to account for less than half but a substantial proportion of agriculture's energy demands. Limiting inorganic fertiliser use can also yield environmental benefits through reduced nitrate pollution and nitrous oxide emissions, and could slow depletion of limited global stocks of phosphates.

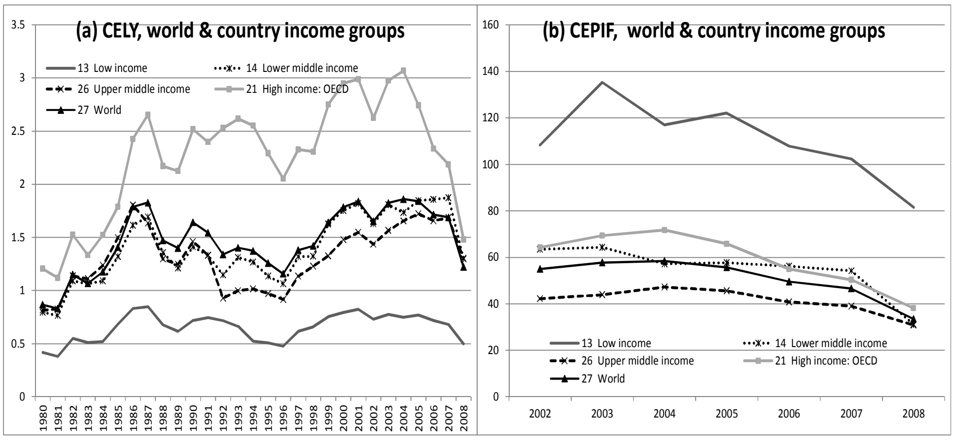

Figure 4 CELY (value added tonnes grain equivalent /ha) and CEPIF (value added tonnes grain equivalent /tonne fertiliser) by country groups

Source: calculated as described in text using international grain prices. Information on fertiliser use only available from 2002 to 2008.

As with CEPALs, cereal equivalent land yield rises steadily in figure 4 from low to high income groups, and has generally risen from 1980 to 2010, , except for low income countries, with the extent of the rise varying between income groups, and with falls during periods of high cereal prices (in the early and late 90s and in 2008) and from 2004 in high income countries. A sudden drop in upper middle income countries' CELY in 1992 appears to be due to an unexplained rise in middle income countries' cereal areas in 1992.

Values for Cereal Equivalent Land Yield (CELY) are heavily affected by land quality. This is not obvious in the income group comparisons in figure 4(a), as there is some averaging of land qualities across countries. However figure A4(a) in annex A shows marked CELY differences across countries – as some countries are able to apply irrigation to obtain two or three crops per year in much of their agricultural land, while in others agriculture may be dominated by extensive low quality grazing lands. The value of this indicator in cross country comparisons is therefore limited. However it has considerable value as an indicator of changes in productivity over time within countries, and for regions and the world as a whole.

Figures 3 and 4 together highlight the challenge facing agriculture in each country and across the world – how to get high income countries' high labour and land productivity (shown by high CEPAL and CELY values in figures 3 and 4a) without high use of fertiliser which leads to low fertiliser productivity (CEPIF) in figure 4(b). On the other hand low income countries are unlikely to achieve high yields and labour productivity with their low rates of fertiliser use - with many crops grown without fertiliser at all, and unsustainable soil mining in some areas. Low income countries will therefore need higher fertiliser use and lower aggregate fertiliser productivity to raise their yields – though there is scope for improving productivity of existing fertiliser use. Major challenges are faced by lower and upper middle income countries as these countries are responsible for the majority of the world's fertiliser use but have low fertiliser productivity. Figure 5 demonstrates these challenges, comparing 2008 global and high income (OECD) countries' CEPAL, CELY[15] and CEPIF with illustrative

[15] CELY is measured per 50ha to provide a comparable scale with CEPAL and CEPIF.

sustainable targets for these variables[16]. Although the precise targets can be debated, figure 5 illustrates well the challenge facing world agriculture – how to dramatically raise both agricultural labour and external input productivity while maintaining land productivity when low external input productivity has been the basis for past achievement of high labour productivity in high income countries' agriculture. Most discussions of the challenges facing world agriculture focus on the need to maintain yields with lower external input use (that is with much higher external input productivity) but pay scant specific attention to the critical challenge of raising agricultural labour productivity (for example (Foley et al., 2011; Foresight, 2011; Godfray et al., 2010b; IAASTD, 2009; Naylor, 2011; Pretty et al., 2011)[17].

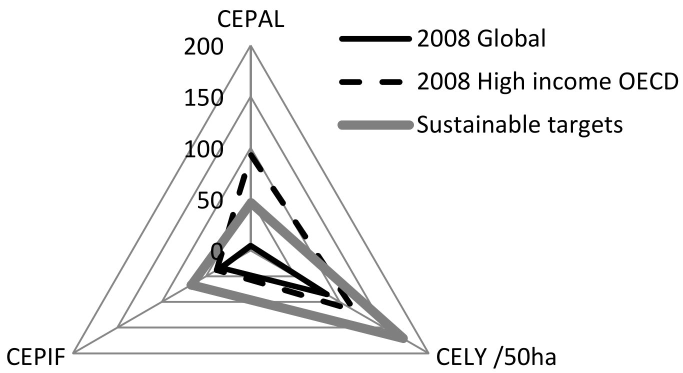

Figure 5 Illustrative sustainable agricultural productivity targets

5. An indicator of real food prices relative to real incomes

Having considered possible indicators for national and international setting and monitoring of agricultural development targets, we now consider possible indicators for monitoring food prices. Indicators should comply with the principles for 'useful' indicators set out at the beginning of the previous section (they should be relevant, based on sound theory, intuitively meaningful, consistently applicable across time and countries, and use (potentially) available data). In addition they should attempt to address the major shortcoming of current widespread use of 'real prices' relative to retail or manufacturing price indices: their failure to represent the 'income effect' of high prices on poor consumers.

The core impact of the 'income effect' of food price increases is a reduction in consumers' incomes available for purchase of non-food goods and services. This is particularly serious for poor people given the limited opportunities they have to substitute cheaper for more expensive foods (since they are already buying cheaper foods) and the large share of their income and expenditure that are

[16] We use a CELY target of 200% of the global 2008 value ((Foley et al., 2011)) with the CEPIF target twice the global 2008 value ((Foley et al., 2011) suggest that agriculture's greenhouse gas emissions need to be reduced by roughly 75%, but current emissions are also caused by tropical deforestation and methane emissions from livestock and rice cultivation). The (somewhat arbitrary) CEPAL target is 50% of the high income (OECD) 2008 CEPAL (ten times the 2008 global value).

[17] The only explicit mention in any of these publications of the need for increases in labour productivity was in (Foresight, 2011) p156 where it was included in a list of potential indicators in a 'food system dashboard'.

typically taken by food expenditures. We therefore propose an indicator, the Food Expenditure Ratio (or FER), which is defined as the expenditure required to meet essential calorific requirements divided by resources available for non-staple food after consumption of essential calorific requirements or

$$\text{FER}=\frac{\text{Essential calorific expenditure}}{\text{Total per capita consumption - Essential calorific expenditure}}$$

The FER varies with per capita consumption, minimum calorific requirements, and calorie prices. We propose that the FER is defined for specific consumption fractiles in a population, with, for example, FERD1 for mean consumption of the first (lowest) consumption decile in a population and FERQ3 for mean consumption of the middle quintile in a population (which may approximate the median consumption of the population). Information on mean incomes and consumption by decile and quintile is increasingly available at country level from LSMS and other surveys, and has been compiled by (WIDER, 2008) and (Solt, 2012).To provide a test and proof of concept, estimates of FERD1 and FERQ3 were developed for selected countries and selected regions of the world by first obtaining rough estimates of the proportion of total consumption by the lowest decile and the mid-quintile (as detailed in annex B). These allowed estimation of the mean per capita consumption in each of the two fractiles as a percentage of total household consumption, which when multiplied by household final consumption expenditure in current US$ and divided by population (from (World Bank, 2011), codes NE.CON.PRVT.CD and SP.POP.TOTL) provided an estimate of mean per capita consumption in each fractile. Essential calorific requirements were specified as 1800kcal per person per day (in line with FAO standards), and expenditure on grain required to obtain this estimated using a standard 3500kcal/kg grain(Shapouri et al. (2009)), and international grain prices (in current US$) estimated with prices and grain index weights taken from (World Bank, 2012).

Figure 6 shows estimated FERD1 and FERQ3 for major regions of the world from 1990, while annex C shows estimated FERD1 and FERQ3 for selected countries in Asia, Latin America and Africa.

In broad terms, the patterns in the figures suggest that the indicator represents well the different impacts of food price increases on different households. In all figures, for example, the FERD1 values are substantially higher than FERQ3 values and more sensitive to food price shocks (as in the mid 1990s and 2007/8). However these differences are less marked in more wealthy economies and in those that have become more wealthy over time, but remain marked in Africa. This is consistent first with the lack of income and agricultural growth in Africa in the 90s (coupled with high gini coefficients as compared with Asia and even Latin America - (Dikhanov, 2005)) and with Headey's observations and argument that the food crisis impacts have been substantially mitigated by economic growth in India and China. A strength of the FER indicator is the way that it takes into account the extent and distribution of economic growth within economies.

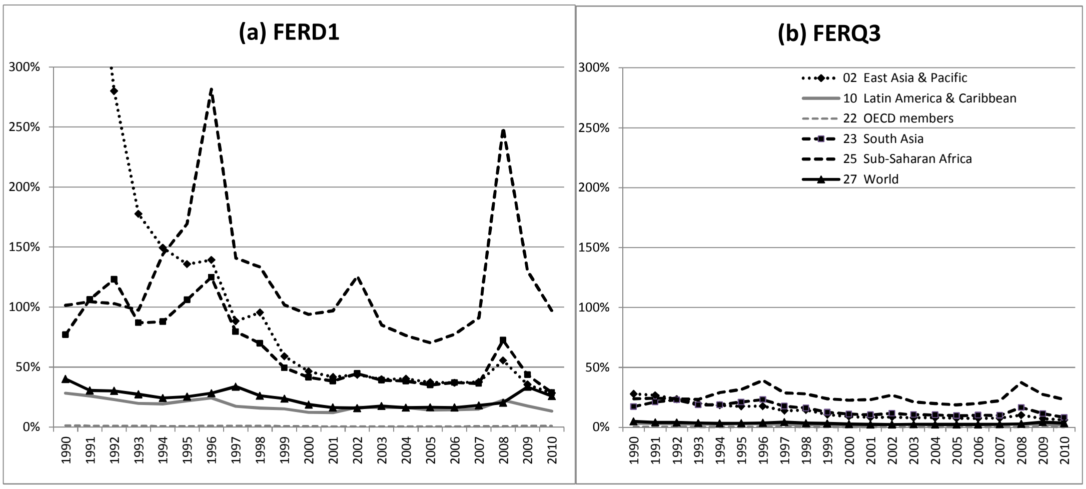

Figure 6 Food expenditure ratios (FERs) for Decile 1 and Quintile 3 by regions

Source: see text

There are, however, some apparent anomalies, such as the very high values for the East Asia Pacific region before 1993. There are substantially more anomalies for FER estimates prior to 1990 and in estimates for some countries (for example Madagascar, Zambia and Cameroon had to be dropped from the annex). There may be a number of explanations for the more extreme values:

- The cost of meeting calorific requirements is calculated using international grain prices. However there is substantial variation in the extent to which international prices are transmitted to domestic markets, and governments may take specific measures to reduce this to protect domestic consumers when international prices are high.
- Weights accorded to different grains are determined by relative international production and consumption patterns, but these will vary for specific countries.
- In poor agrarian economies with significant numbers of poor food deficit producers, a substantial proportion of their calorific requirements may not be purchased, reducing their vulnerability to price increase (although capital constraints and hungry periods may mean that price increases nevertheless affect them very badly)
- When faced with serious price increases poor people do switch from more diverse diets and reduce their intake particularly of more nutritious food. They also borrow, draw down on savings and sell assets to maintain essential food intake, as well as reduce their non-food expenditures.
- The estimate used of first decile share of consumption in sub Saharan Africa may well be too low (see annex 2). Raising the income share lowers the graphed FERD1 for sub Saharan Africa across all years, but does not change Africa's pattern of greater variability and less general improvement over time

The principal ways in which the calculations and estimates presented here could be improved would be with:

- use of domestic rather than international prices;
- use of country specific weights across different grains (and staple roots and tubers)
- improved estimates of decile and quintile incomes within and across countries;

- allowance for consumption of some livestock products as 'essential' in less poor countries and among less poor consumers in low income economies.

However, as figure 5 shows in comparison with figure 1, the relatively rough and ready trial estimation presented here captures a number of important features about real food prices measured in terms of opportunity cost of non-food expenditures allowing for income effects, particularly for the poor ((Dorward, 2012a)). It also allows for global regional and country analysis concerned about food insecurity, poverty reduction and economic development and offers substantial advantages over current calculations of 'real prices' deflated by price indices.

6. Post 2015 international indicators and goals

The two previous sections of this paper have proposed and tested four measures of agricultural productivity and of food prices, measures developed to address current gaps in suites of commonly used measures and failings in measures that are used. We now briefly discuss these measures in the context of growing interest in what should follow the MDGs after they expire in 2015.

Debate on successors to the MDGs has followed two main strands: assuming that some international global agreement is needed on global challenges, first what process should lead to the establishment of goals, and second what challenges should be addressed (what goals, targets and indicators should be established). The two strands are connected, in that the process should determine what challenges are focussed on, but they can and should also be pursued independently – all stakeholders, in whatever process of goal, target and indicator establishment should benefit from informed analysis and discussion of these issues[18].

The four measures proposed in this paper specifically address calls for a post 2015 international agreement to include explicit attention to the problems of agriculture, the environment, sustainability, equity, jobless growth and food security; to integration and holism across and within sectors; to aggregate and disaggregated targets and indicators that promote accountability; and to changes needed as regards production and consumption within high as well as middle and low income economies (for example (BOND, 2011; Global Call to Action Against Poverty (GCAP) et al., 2011; Melamed, 2012a, b; Waage et al., 2010)). In this CEPAL is specifically concerned with jobless growth and equity, its integration with CELY and CEPIF provides holistic attention to the environment, sustainability and growth in high as well as low and middle income countries (as in figure 5). The FERD1 is concerned with the effects of food price changes on equity and food security. All the measures have been examined at both global, regional or income group and national scales of aggregation and disaggregation. Furthermore, they comply with principles for 'useful' indicators set out earlier. There is, however, need for substantial improvement in the coverage and reliability of some national and international statistics and statistical systems – for example there are widely recognised difficulties with international statistics on agricultural production and areas (for example (Headey, 2011)), with gaps in coverage of income and expenditure surveys and domestic price information and, as noted earlier, in standard definitions of variables such as 'agricultural employment'. Assimilation of these indicators into post 2015 goals and targets could therefore not only utilise existing data on these issues, but also stimulate improvements in information on them in

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[18] Discussion will also be framed by fundamental questions regarding the purpose of a post-2015 agreement in a very different global context from the one that framed the MDGs ((Melamed, 2012a)).

the future (an important side benefit of the MDGs was improved information on some topics, (Waage et al., 2010))

7. Conclusions

This paper has examined the roles of falling of food prices relative to wages in wider economic growth and development. These roles have a long history in in the development economics literature, but their consideration seems to have been surprisingly absent from debates about the impacts of high food prices on development (impacts which have commonly been seen as beneficial, through their role in stimulating research investment).

The 'need' for low food prices to stimulate wider economic growth highlights the importance of raising the productivity of agricultural labour in the economy, particularly in smallholder agriculture, which offer critical but temporary and challenging opportunities. However agricultural labour productivity has also been widely overlooked in recent policy and faces considerable challenges. These arise not only in the need for governments and the global community to recognise the public good characteristics of agricultural productivity and promote investment in agriculture despite (indeed to encourage low prices), but also because environmental challenges require a simultaneous fall in fossil fuel and material inputs which have historically been a major contributor to rising land and labour productivity. Related to this is a need for indicators that provide better measures of different types of agricultural productivity and of food price impacts on particularly poorer people.

Two sets of indicators proposed in the final sections of the paper go some way to meeting this need. These could be widely implemented, for example supporting new international development goals when the current Millennium Development Goals expire in 2015. They would require limited further development and cost, since many of their basic elements are already found within national and international data systems, but they could support important improvements in these systems. Further challenges in agricultural policy, and in the development of related indicators, need to be addressed in, for example, links between agriculture and food systems on the one hand with energy, water use, climate change, land institutions and access, and micro-nutrient deficiencies and diet related non-communicable diseases.

Annex A: Country estimates of Cereal Equivalent Productivity Indicators

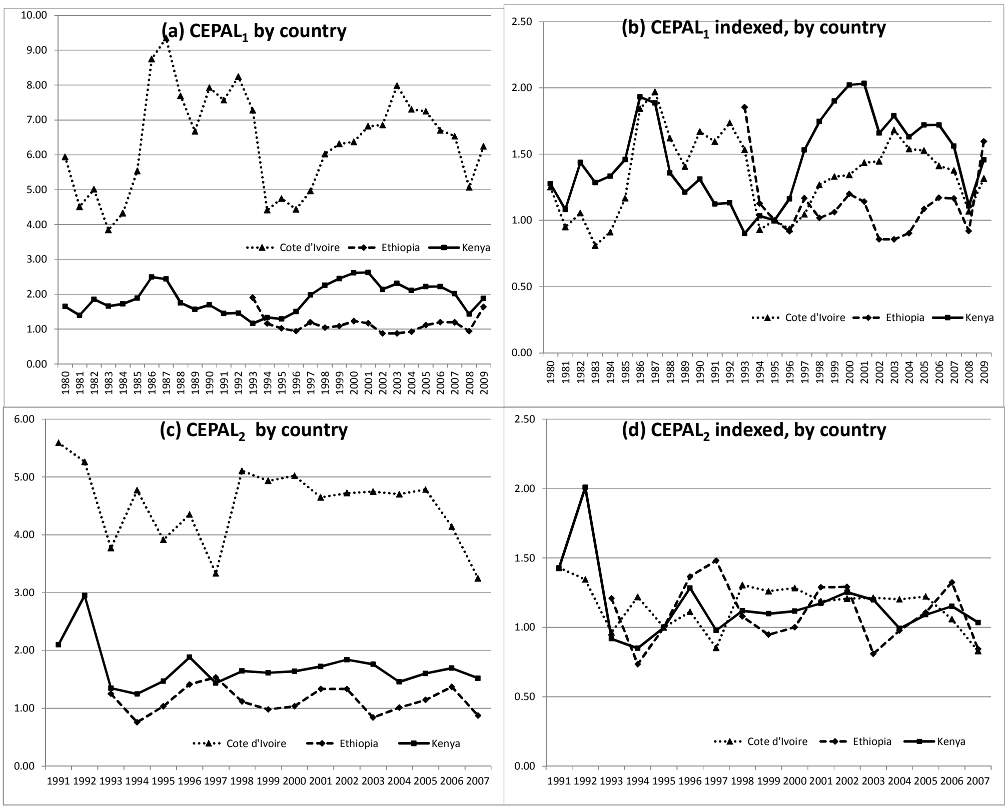


Figure A1: CEPAL estimates for selected African countries using international prices (a and b) and domestic producer prices (c and d)

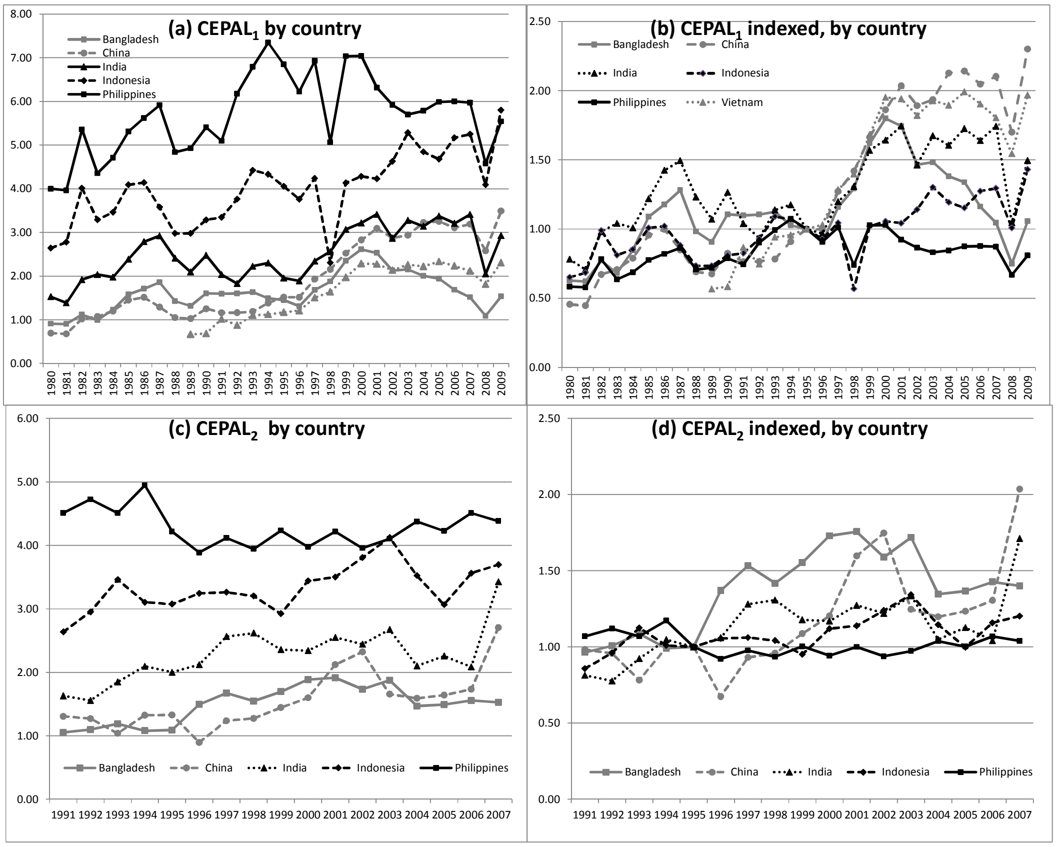


Figure A2: CEPAL estimates for selected Asian countries using international prices (a and b) and domestic producer prices (c and d)

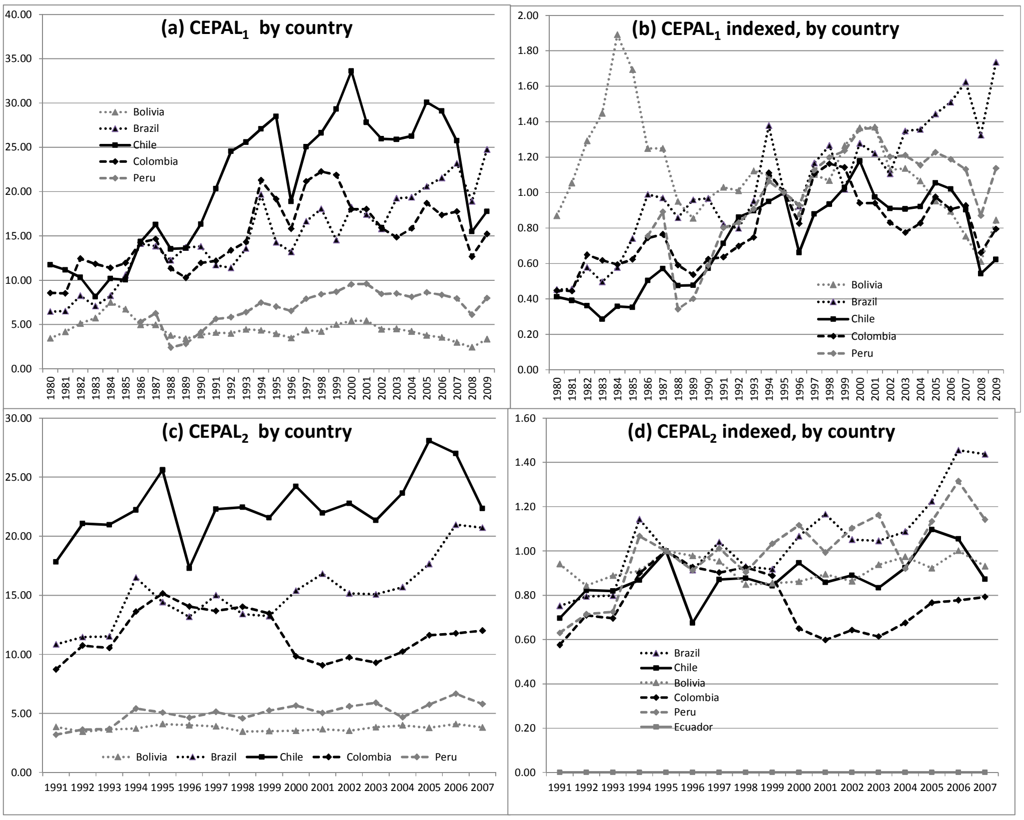


Figure A3: CEPAL estimates for selected Latin American countries using international prices (a and b) and domestic producer prices (c and d)

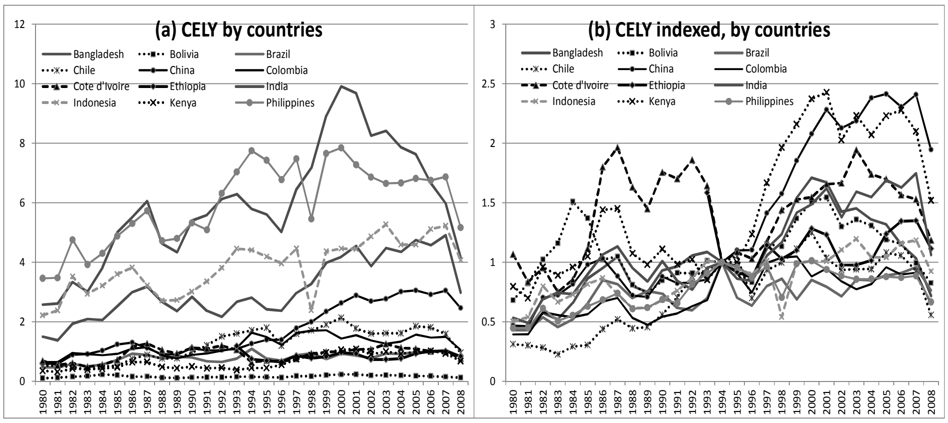


Figure A4: CELY, raw and indexed estimates for selected countries

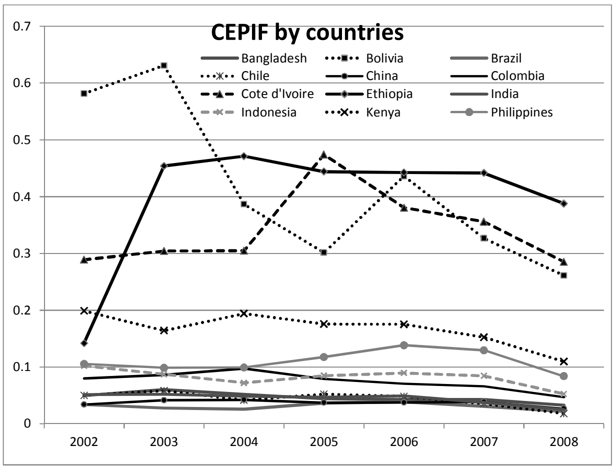


Figure A5: CEPIF estimates for selected countries

Annex B: Methods and data used in calculating Food expenditure ratios

Estimates of Food Exopenditure Ratios were developed in three stages:

1. Estimation of decile and quintile consumption shares
2. Estimation of mean consumption per capita for decile 1 (D1) and quintile 3 (Q3)
3. Estimation of minimum calorific expenditure requirements

We describe each of these in turn.

1. Estimation of decile and quintile consumption shares

Owing to differences in data available on consumption distribution within countries and across regional and global populations, different methods were used for country estimation and for regional and global estimation.

1.1 Estimation of decile and quintile consumption shares by country

Gini coefficients and information on decile and quintile shares were obtained from (WIDER, 2008) which reports Gini coefficients and decile and quintile shares from different surveys in different countries and years, but does not provide complete sets of country estimates by year. To obtain a approximate estimates of annual decile and quintile shares, these were regressed on gini coefficients. A scatter plot suggested a strong correlation between Gini coefficients and decile and quintile shares (see figure A2.1)

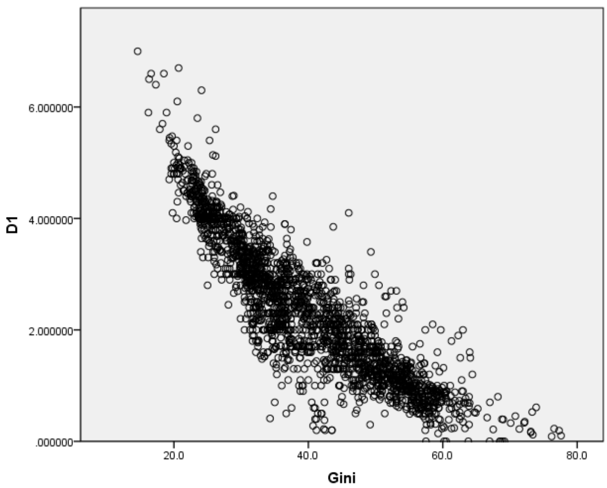


Figure B1: Scatter plot of decile consumption shares against Gini coefficents

Decile and quintile shares were then regressed on gini coefficients. Log linear, quadratic and cubic functions were estimated. A slightly better fit was obtained with data on individual consumption as compared with income, with a cubic functional form for decile 1 income share, while a simple linear form gave the best fit for the quintile 3 income share. Selected equations are shown in table A2.1.

Table B1 Regression estimates of D1 and Q3 consumption shares on Gini coefficients

Dependent variable	D1 consumption share	Q3 consumption share
Coefficients		
Constant	5.54	23.86
G		-23.05
G^2	-29.76	
G^3	27.74	
R^2	0.853	0.792
N	293	130

Counties were then inspected to determine how many gini coefficient estimates were contained in the database. For those with three or more, interpolation was used to estimate ginji coeffcients for missing years. These gini coefficients were then used to estimate the relevant decile and quintile income shares, using the regression equations in table A2.1.

1.2 Estimation of regional and global decile and quintile consumption shares

There is a considerable literature and debate on estimation of global income and consumption distribution (for example (Dikhanov, 2005), (Palma, 2011), (Milanovic, 2006), (Sala-i-Martin, 2006), (Anand and Segal, 2008), (Milanovic, 2009), Palma (2011)). For illustrative purposes regional and global estimates of decile and quartile income shares were taken from (Dikhanov, 2005). It should be noted that Dikhanov's estimate of the gini coefficient for sub Saharan Africa appears to be markedly higher than that of Anand and Segal.

2. Estimation of mean consumption per capita for decile 1 (D1) and quintile 3 (Q3)

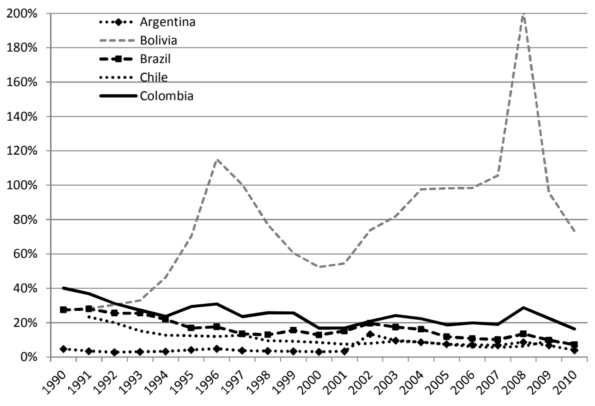
Dividing the estimates of decile and quartile consumption shares derived as above by 0.1 and 0.2 respectively allowed estimation of mean decile and quartile per capita consumption as a percentage of the mean per capita consumption for population as a whole. This was then multiplied by household final consumption expenditure in current US$ and divided by population (from (World Bank, 2011), codes NE.CON.PRVT.CD and SP.POP.TOTL) to give estimates of mean per capita consumption in current US$.

3. Estimation of minimum calorific expenditure requirements

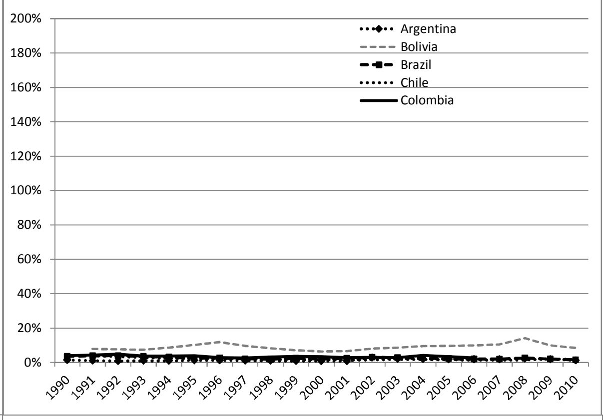
Essential calorific requirements were specified as 1800kcal per person per day, in line with FAO standards, and expenditure required to obtain this from grain estimated using a standard of 3500kcal/kg grain ((Shapouri et al., 2009)), with international grain prices (in current US$) estimated with prices and grain index weights taken from (World Bank, 2012).

Annex C: Country estimates of Food expenditure ratios

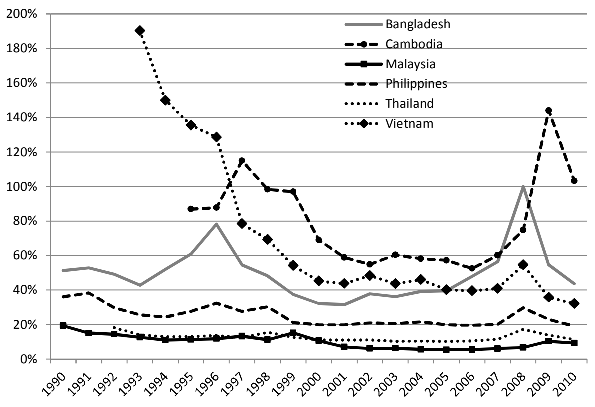
FERD1 selected Latin American countries



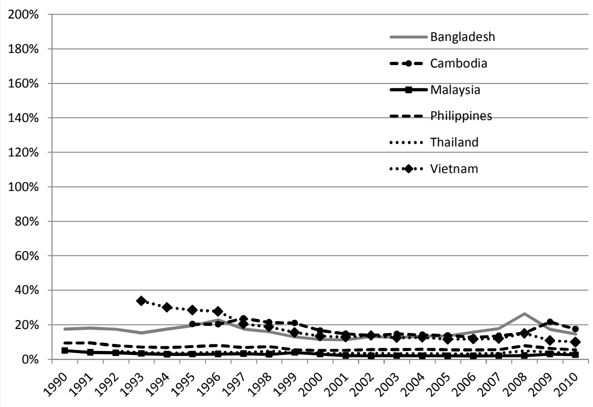
FERQ3 selected Latin American countries



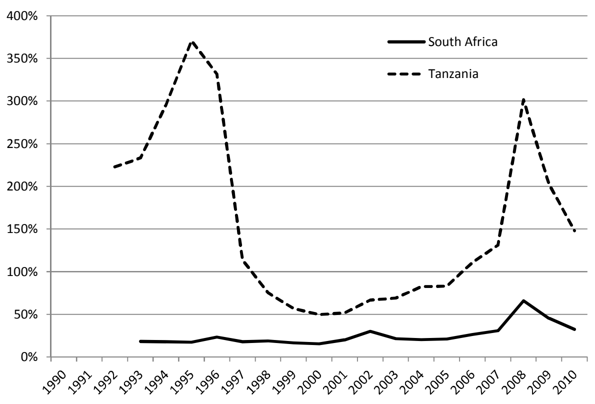
FERD1 selected Asian countries



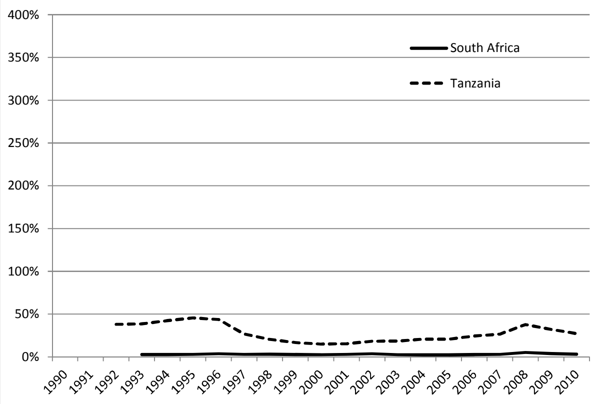
FERQ3 selected Asian countries



FERD1 selected African countries



FERQ3 selected African countries



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