

How can agricultural interventions contribute in improving nutrition health and achieving the MDGs in least developed countries?

Andrew Dorward

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SOAS, University of London
&
Leverhulme Center for Integrative Research in Agriculture and Health

Abstract

There are strong conceptual linkages between agricultural development and nutrition improvements which may be categorised into three main pathways: the development, own-production and market pathways. Evidence on the efficacy of these pathways is mixed with some strong, some negative and some weak impacts. These findings reflect both the importance of agriculture for nutrition and the conditionality of that importance on contextual factors. They are also the result of insufficient high quality empirical research investigating these linkages. The most effective 'pathways' and interventions linking agricultural change to improved nutritional outcomes change with economic growth and development, with declining importance of the development and own-production pathways and increasing importance of the market pathway. Substantial challenges in operationalizing agricultural-nutrition linkages need to be overcome to better exploit potential opportunities.

How can agricultural interventions contribute in improving nutrition health and achieving the MDGs in least developed countries?

Andrew Dorward
SOAS, University of London
and
Leverhulme Center for Integrative Research in Agriculture and Health

1. Introduction

This paper discusses ways in which agricultural interventions can contribute to improving nutrition health and to achieving the MDGs in least developed countries. It does not consider agriculture linkages to over-nutrition, obesity and associated NCDs as these issues do not feature in the MDGs. After this introduction the paper briefly details the main nutrition and agriculture related MDGs and progress on their achievement. The following section then considers processes by which agriculture may contribute to improved nutrition and to progress on nutrition related MDGs. This is followed by an examination of evidence on the impact of agricultural development and development interventions on nutrition. This leads on to a discussion of agricultural interventions that can promote improved nutrition – sometimes referred to as nutrition-sensitive agriculture.

2. What are the nutrition / health issues in the MDGs that are most closely linked to agriculture?

The Millennium Development Goals, a set of eight goals with 18 associated targets and 48 indicators, were originally specified in United Nations (2001). A small number of further targets and indicators were added subsequently.

The principle goal and target that is the focus of this paper is Goal 1 (eradicate extreme poverty and hunger) and within that target 1C (halve, between 1990 and 2015, the proportion of people who suffer from hunger). Two indicators are specified for this target:

- Indicator 1.8: prevalence of underweight children younger than 5 years
- Indicator 1.9: proportion of population below minimum level of dietary energy consumption

The most recent information on progress and likely achievement or non-achievement of MDG targets is found in United Nations (2012). Substantial gains have been made on indicator 1.8 in some regions (notably Western Asia, Eastern Asia, Caucasus and Central Asia and Latin America and the Caribbean, and to a lesser extent in North Africa and South Eastern Asia). However progress has been slower in Sub Saharan Africa and South Asia, and the overall target of halving the prevalence of under-nourishment is unlikely to be met by 2015.¹

¹ This discussion of MDG achievements does not address widely voiced concerns about differences between changes in incidence and absolute numbers or about greater challenges in

With regard to indicator 1.9, there have been considerable concerns about the validity of measures for indicators used for ‘the proportion of population below minimum level of dietary energy consumption’ – the incidence of hunger and under-nourishment. In 2012 the FAO released revised estimates of the numbers and proportions of undernourished people (FAO et al., 2012). These are summarised in figure 1. These revised estimates show that prior to 2007 falls in the prevalence of undernourished people were not quite sufficient to meet the MDG target, and food price increases in 2008 and subsequent years then further slowed down the rate of fall in incidence². However absolute numbers of undernourished people have hardly fallen, meaning that the World Food Summit global target of halving the number of hungry people from 1990-92 to 2015 will be missed by a very wide margin.

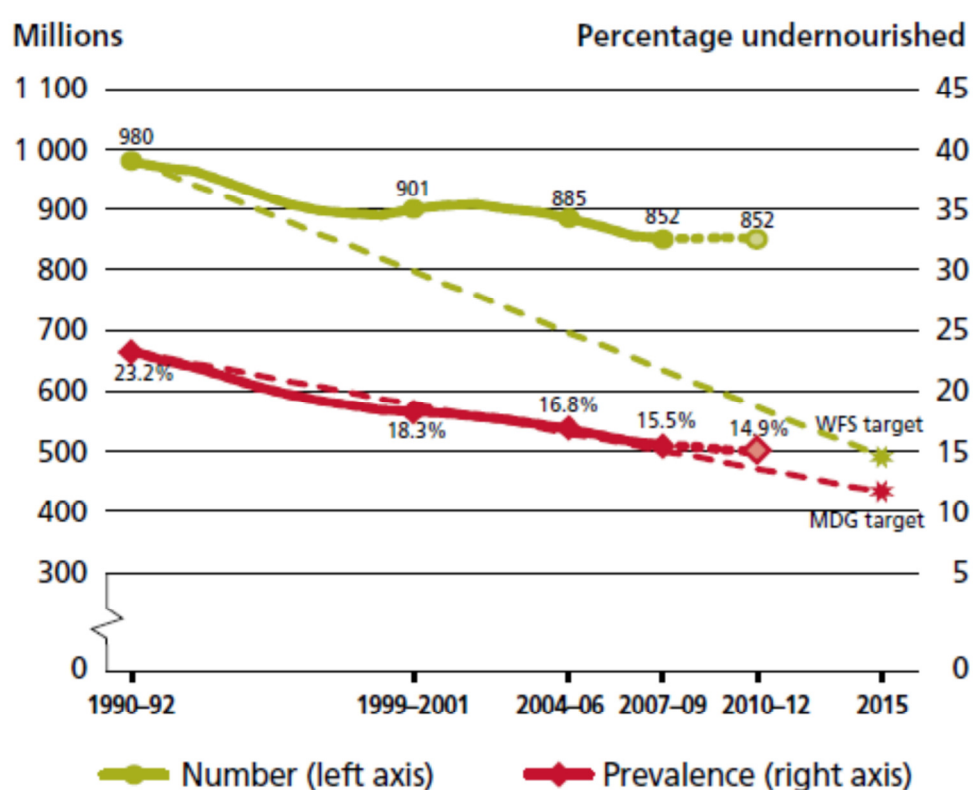


Figure 1 Undernourishment in the developing world

Source: FAO et al. (2012)

meeting relative rather than absolute reductions where countries or regions have initially high incidences of disadvantage (see for example Waage et al., 2010).

² FAO’s recent assessment increases the estimated prevalence of undernourishment in both 1990–92 and subsequent years as a result of allowance for retail food losses and (to a lesser extent, especially in later years) of changes in estimated populations and their dietary needs and supply. However it is stressed that the definition of ‘undernourishment’ is conservative in its definition of minimum dietary needs assessed as the calorific needs to support a sedentary lifestyle (ignoring other dietary needs and the effects of an active lifestyle) over a period of a year (ignoring the effects of acute shortages) (FAO et al., 2012).

The revised estimates of prevalence of undernourishment show a decline rather than the previously estimated reversal in falling global prevalence of undernourishment (FAO et al., 2012) following food price rises in 2008 , as also reported by Headey (2011b).

As with other MDG targets, there are wide variations between regions as regards changes in prevalence and numbers of under-nourished people. FAO et al. (2012) estimate that absolute numbers of under-nourished people have been falling in Asia and in the Latin America – Caribbean areas, with falls in prevalence on track to meet the MDG target. In both Near East/North Africa and Sub Saharan Africa, however, absolute numbers of undernourished people have been rising, with lower falls in prevalence in Sub Saharan Africa, but actual increases in prevalence in Near East and North Africa – although this is from a much lower 1990-92 starting point than the other regions (7% as compared with 15% in Latin America/ Caribbean, 25% in Asia and 35% in Sub Saharan Africa). Within Asia there has been a remarkable fall in prevalence in South Eastern Asia from 30% to 11% from 1990-92 to 2010, with a slightly lower but still remarkable fall in Eastern Asia from 21% to 12% over the same period. South Asia achieved a lower fall in prevalence, however, which if continued will not be enough to achieve the target. Prevalence in Western Asia increased.

FAO et al. (2012) recommend that under-nourishment and hunger should be monitored with a wide range of indicators of food availability, access and utilisation. Data are not available on an annual regional basis for many critical indicators, such as stunting and wasting (indicators of more chronic and acute under-nutrition). Other goals, targets and indicators related to nutrition in different ways (in that they may represent possible causes or effects of under-nutrition) are reduction in poverty incidence (Goal 1, measured as the proportion of people living on under \$1.25 per day); reduction of the under five mortality rate (Goal 4); combatting HIV/AIDS, malaria and other diseases (goal 6); and improving access to improved water and sanitation (goal 7). Considerable progress has been made in achieving targets across all regions under goals 1 and 6, and in improving access to improved water (goal 7) though in all cases with continuing wide disparities between regions as regards current status³. There is insufficient progress to meet targets of two thirds reduction in child mortality or in halving the proportion of the population without access to improved sanitation. There are marked rural - urban disparities in all these measures (except for combatting disease on which data is not available), and these disparities are also found as regards the proportion of underweight children.

³ Global progress on poverty reduction is strongly influenced by progress in China, although all parts of the world except Sub Saharan Africa and India had by 2008 already achieved the main MDG1 target of halving the percentage of people living on less than \$1.25 a day (United Nations, 2012). Indicators of labour productivity (one of the indicators used for assessing progress on the second MDG1 target to achieve full and productive employment and decent work for all, including women and young people) shows a very similar global and regional pattern to reduction in poverty incidence.

3. How can agriculture contribute to improvements in nutrition?

There is a burgeoning literature on links between agriculture and nutrition. We examine in this section possible links from a more conceptual angle, and in the next section examine some of the evidence on the importance and nature of these links.

Links between agriculture and food security have long been recognised. There have, however, over the years been major shifts in understanding that have led to recognition that agriculture is only one contributor to food security, and a large number of definitions of food security. A recently stated and widely accepted example is provided by Committee on World Food Security (2012):

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability. The nutritional dimension is integral to the concept of food security

This definition recognises that food availability is, in a broad sense, a necessary but not sufficient condition – access is also necessary through entitlements (allowing local unavailability to be overcome by purchases), and once accessed food needs to be utilised. Utilisation depends upon food storage and processing and upon physiological processes of nutrient absorption. Stability is then needed in expected food access – and hence stability in availability, access and utilisation and in their determinants. Food security also has different dimensions as regards types of nutrient. Although food security is often considered in terms of calorific supply (as for example in the MDG and WFS targets to reduce undernourishment), increasing recognition of the need to consider protein and micronutrients has not yet been recognised in these targets. Links between food security and nutrition have also long been recognised. Current increasing recognition of the links between agriculture and nutrition is therefore overdue.

A number of authors have provided overviews and conceptualisations of links between agriculture and nutrition or, more widely, health (for example Fan and Brzeska, 2011; Hawkes et al., 2012; Headey, 2011a; Hoddinott, 2012; Pinstруп-Andersen, 2012).

Hawkes et al. (2012) provide a conceptual framework that helpfully encompasses the main agriculture – nutrition linkages (Figure 2). This sets out broad links between different elements in the agri-food system (in the column on the left) and the more proximate determinants of nutritional status (in the central column). These are also affected by indirect impacts and intervening factors (in the right hand column). The agri-food system, more proximate determinants of nutritional status, and the indirect impacts and intervening factors are all affected by culture, gender, equity, policy, governance, climate, the natural environment, and the political and economic context.

Research chain for agriculture and nutrition

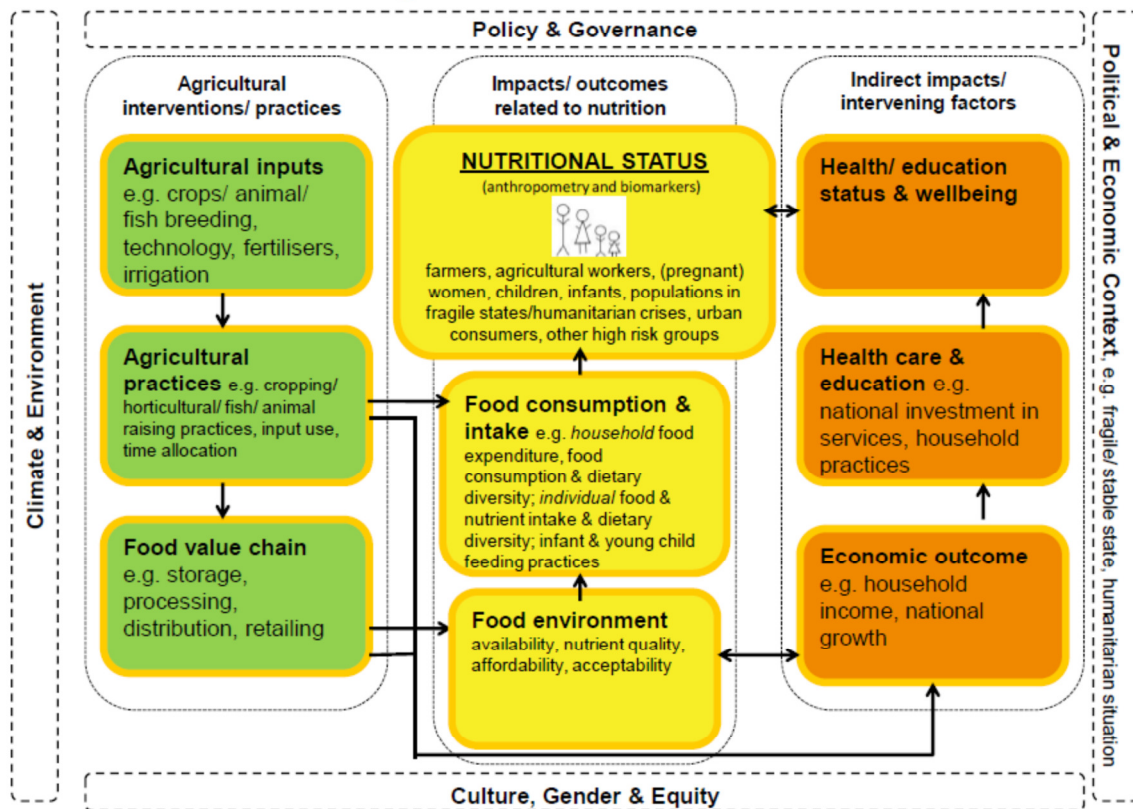


Figure 2 A broad conceptual framework of agriculture- nutrition linkages

Source: Hawkes et al. (2012)

Within this overview it is helpful to distinguish between and examine in more detail three broad pathways by which agriculture impacts on nutrition: a general development pathway, a market pathway, and an own- production pathway⁴. We consider these in turn.

There is a long standing literature on the role of agricultural development in wider development processes (for example Johnston and Mellor, 1961; Mellor, 1995; Timmer, 1988) supported by more recent empirical work (for example Christiaensen et al., 2011). Dorward (2013 (forthcoming)) summarises this as a process whereby new agricultural technologies and resources increase both agricultural production and food availability per worker. This lowers the cost and price of food relative to worker incomes and increases real incomes and other discretionary spending. It also releases agricultural labour from food production to production of other goods and services (see figure 3). Industrial, service and knowledge revolutions can then build on this with further increases in labour productivity and in goods and services supply and demand, with falling relative importance of agriculture. Expected food security and nutritional benefits from this arise from increased food production (improving food availability), lower food prices and

⁴ This builds on the distinction between market and own-production pathways identified by Dorward and Dangour (2012)

increased real incomes (improving food access, both for staples and more diverse nutrient rich foods) and more diverse incomes (improving food stability). Increased individual and public incomes should also lead to improved individual and public educational, health, sanitation and other investments which should lead to improved food utilisation. These development processes should therefore lead to improvements in all four 'pillars' of food security⁵.

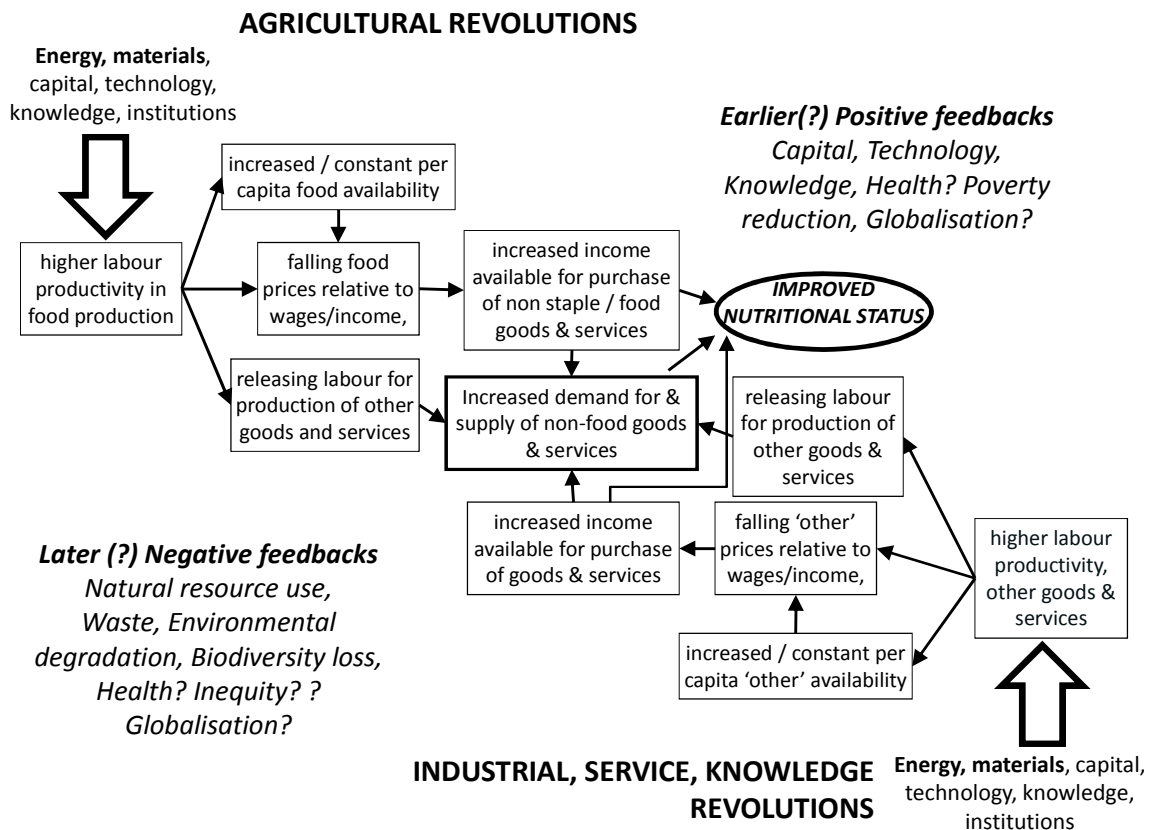


Figure 3 Agricultural development processes
Source: Adapted from Dorward (2013 (forthcoming))

These arguments suggest that despite its challenges there is a special role for smallholder agricultural development in poor agrarian economies with large numbers of poor farmers: such development leads to simultaneous expansion of labour supply to and demand for initially non-staple and then non-farm production with simultaneous food security (and nutritional) gains for poor smallholder populations. The effectiveness and efficiency of smallholder development policies and investments is, however, questioned by some, who suggest that faster growth may be achieved by focussing on non-agricultural growth and/or large scale agricultural development (for example Collier and

⁵ Discussion here focuses on addressing problems of under-nutrition. Many of the agricultural impacts discussed under this pathway, and under the other pathways, can also unfortunately lead to problems of over-nutrition and obesity (Prentice, 2006; Webb and Block, 2012).

Dercon, 2009). These arguments rely on prior or current agricultural development that has already raised agricultural productivity outside the poor agrarian economy to deliver cheap food (from imports or from rapid increases in labour productivity - measured as value added, net of other costs - in large scale agricultural development,) with simultaneous non-agricultural development to absorb smallholder labour and raise its productivity outside the agricultural sector. This in turn requires competitive access to markets serving populations with sufficiently high incomes to demand the new goods and services produced. Both these alternatives face substantial challenges as regards large scale requirements for improved access to food markets and for labour absorbing non-agricultural development. Large scale social protection policies may be used to address some of these challenges (as in Brazil) as policy makers may try to produce the same coordinated processes with taxes and subsidies transferring income to large numbers of poor rural people from smaller numbers of skilled workers and owners of capital. This approach, however, faces governance and political economy challenges and needs a large and rapidly growing capital intensive sector to support these transfers.

There are also questions about the availability of cheap food. International food price spikes from 2008 have led to renewed interest in food prices and challenged the widespread observation of a steady fall in long term real food prices, as it was then observed that prices had in fact flattened out from the early 2000s, before the 2008 spike (Piesse and Thirtle, 2009), and they have since fluctuated above a base somewhat above pre-2008 prices. More fundamentally, however, it is important to recognise that conventional measures of 'real' food prices compare food prices with US consumer prices or the prices of manufactures, prices that are largely determined in richer economies by the demand of richer consumers and societies (with relative falls in food prices an inevitable result of increasing incomes with economic growth (Dorward, 2013 (forthcoming); Dorward, 2011)) . A more meaningful measure of real food prices is to compare them with incomes, which of course vary between rich and poor individuals and societies. Unsurprisingly real international food prices measured in this way have not declined for poor people in the way that they have for the less poor (see figure 4).

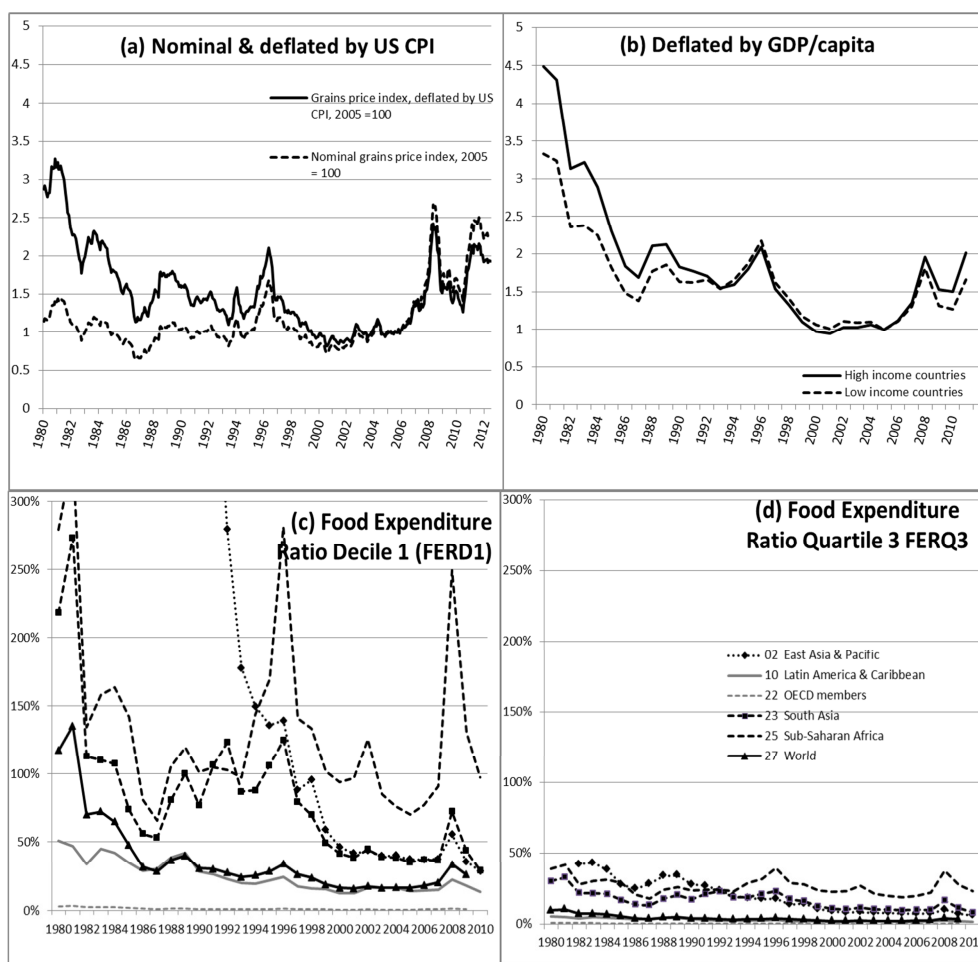


Figure 4 Food price changes 1980-2010 with different measures for different income groups⁶

Source: Derived from Dorward (2013 (forthcoming))

The 'market' and 'own-production' pathways are shown in figure 5. Both these pathways postulate the effects of agricultural interventions (on the left of the figure) which, if taken up, lead to agricultural product changes. Under the market pathway (which focusses on consumer impacts) these product changes then lead to changes in the supply to the food market, with possible subsequent impacts on food prices, consumer real incomes and food demand and consumption, again with possible subsequent impacts on nutrition intakes, food utilisation and nutritional status. There are strong parallels between the market pathway and some of the processes outlined under the agricultural development

⁶ The lower panel in Figure 4 shows Food Expenditure Ratios or FERs for different income groups (the lowest decile and the middle quartile in panels (c) and (d) respectively, where the FER is the ratio between expenditure on a minimal calorific requirement from staple foods (in this case grains at international prices) and remaining income available for non-staple and non-food expenditure. See Dorward (2013 (forthcoming)) for further details and for a discussion of the strengths and weaknesses of FER measures. 1980-1990 FER estimates shown here (except for East Asia and the Pacific) for comparison with other food price measures are not included in Dorward (2013 (forthcoming)) due to doubts about data quality and should be used with care.

pathway. However the market pathway is not restricted to economies with large numbers of poor farmers, and focusses more on agricultural impacts on the nutrition of food buyers.

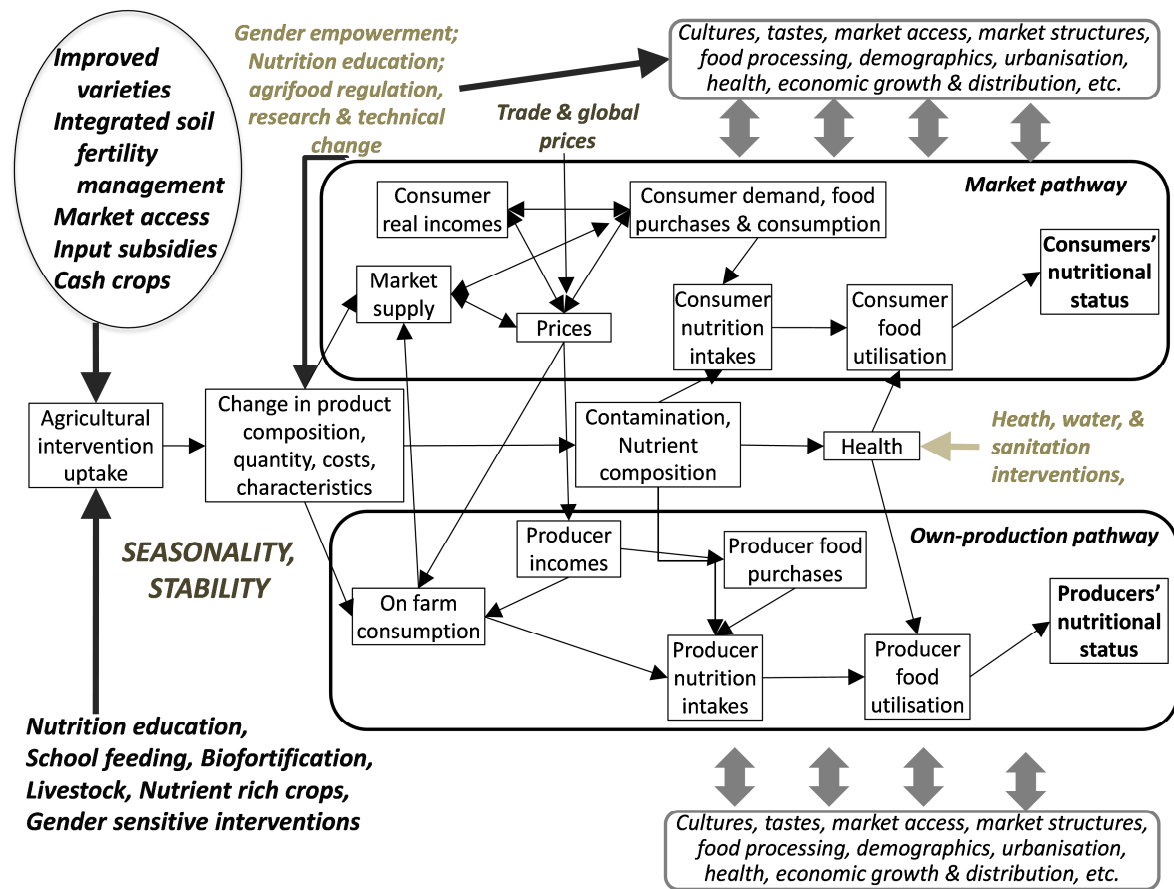


Figure 5 Market and own-production pathways for agricultural impacts on nutrition

The own-production pathway focusses more on impacts on agricultural producers and ways in which it impacts their food consumption and nutritional status – allowing for the effects of increased incomes from food or non-food sales and/or own changes in consumption of own produced foods. Both the market and ‘own-production’ pathways are affected by wider socio-economic context (shown at the top and bottom of the figure) and by health impacts of health, water and sanitation interventions (shown in the middle of the figure). It is also worth noting the potential impacts of food contamination on these pathways (possible impacts on demand are not shown).

The discussion above may appear to suggest that these three pathways can be considered to be relatively distinct from each other. Examination of their components, however, shows that there are considerable overlaps between them – for example the ‘development pathway’ depends upon processes that are very similar to those involved in the ‘market pathway’, while figure 5 shows commonalities and linkages between the market and own-production pathways. The different pathways can therefore be considered as both distinct and overlapping, as shown in figure 6 (which also shows

important non-agricultural and contextual influences on nutritional status, from figures 2 and 5, and with the development pathway involving both agricultural and non-agricultural growth, in its lower and upper parts). We discuss later how the effectiveness of different pathway and pathway combinations identified in figure 6 may vary in different contexts, and the implications of this for interventions promoting agri-nutrition linkages.

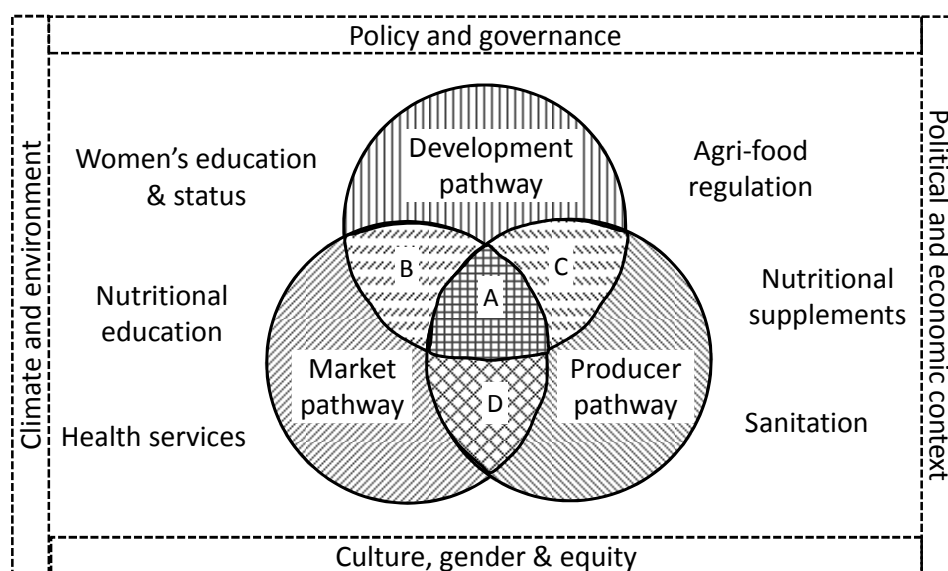


Figure 6 Overlaps between development, market and own-production pathways for agricultural impacts on nutrition

4. How has agriculture contributed to improvements in nutrition?

We now turn to consider the evidence for agriculture’s actual impacts on nutrition by these three pathways (including evidence of agriculture’s impacts on intermediate steps towards food security and improved nutritional status). As one would expect, there are considerable overlaps in evidence across the three pathways, but also considerable gaps and difficulties in clearly establishing patterns of causality.

Evidence on the first pathway is derived from two main types of study: those that analyse patterns of change across countries with different growth paths (for example Headey, 2011 #11; Webb, 2012 #8) and those that look at growth paths in more detail within particular countries (for example Pauw, 2012 #18). Different studies also examine changes in and relations between different elements in the processes by which agriculture may contribute to growth and improved nutritional status.

Considering first studies analysing patterns of change across countries, a number have investigated the relationship between income growth and nutrition, generally measured in terms of stunting, height for age or under weight. These generally find that increasing income leads to reduced malnutrition, although estimates of the strength of the relationship vary. Some studies provide some explanation of this variation, with stronger effects in longer term analysis, stronger effects from agricultural growth (except in India), and stronger effects at lower income levels. Effects are also commonly stronger when malnutrition is measured by hunger or dietary intake than when it is measured by

anthropometric variables. These findings apply both across countries over time, and in household surveys within countries. There are, however, substantial variations in the strength of the relationship, and nutritional status is also affected by the type of agriculture and by a range of conditioning factors including women's education and status, distribution of growth, dietary quality, land distribution, access to medical care, fertility, infrastructure, and specific nutrition programmes (Ecker et al., 2012; Fan and Brzeska, 2011; Haddad et al., 2003; Headey, 2011a; Pauw and Thurlow, 2012; Smith and Haddad, 2000; Webb and Block, 2012). Headey (2011a) concludes that 'economic growth is nutrition-sensitive if it increases food production (especially when food insecurity is high), reduces poverty, increases female education, improves health access, and reduces fertility rates (a proxy for various family planning outcomes)... for low-income countries at least, economic growth is a necessary but insufficient condition for reducing malnutrition'⁷.

Data and estimation difficulties and the many influences on growth impacts on malnutrition mean that estimates of the scale of these impacts should be treated with care. It is nevertheless instructive to note the scale of the different estimates reported by Headey (2011a), who considers in some detail the variability and reliability in his estimates. Considering first overall growth, his regression estimates suggest that with a per capita growth rate of 5 percent per year, stunting prevalence would be reduced by around 0.9 percentage points per year - or if GDP per capita were to double then stunting would fall by about 18 percentage points. If agricultural and non-agricultural growth are separated, then agricultural growth per total capita of 5 percent per year outside India would reduce stunting prevalence by 4 or 2 percentage points depending on the way that the sectors are weighted (using GDP or employment shares). These are very large impacts. No significant effect of agricultural growth on stunting prevalence is found in the Indian states. Headey also estimates impacts of agricultural growth on estimated energy supply (with a 5% increase in agricultural GDP per total capita leading to 2.5 to 4% increases in energy supply, declining sharply as agricultural population shares fall and calorie consumption rise) and the impacts of increases in daily energy supply and of food production (measured by value per capita) on stunting. He estimates that a 10 percent increase in energy supply is associated with a reduction in stunting of 3.3 percentage points. Increases in food production have a similar impact for the group of countries with initial food production below the sample mean of \$150 per capita per year. They are not, however, significant and are very low for the group of countries with initial food production above the mean.

The studies reported above are relevant to all three pathways by which agriculture can impact on nutrition – and indeed emphasise the relationship and overlap between them. It is also useful, however, to distinguish between them. Considering first the development and market pathways,

⁷ Agricultural development can also, of course, have negative effects on nutrition as for example when it reduces the time that women have for child care or through impacts on the incidence of obesity (Webb and Block, 2012)

- Market pathways will generally involve more direct and immediate impacts of changes in food prices and food composition and less extensive processes of change. The development pathway, on the other hand, involves wider, medium to long term processes including the effects of structural change, changes in agricultural and non-agricultural productivity, and impacts on individual and public resources and investments
- Development pathway impacts are more important in poorer, low and middle income countries as noted earlier, but market pathways can also be important in high income countries
- It might be thought that the development pathway has greater emphasis on price effects than on composition effects as compared with the market pathway, but as noted above questions about composition of agricultural products can also have important effects on the impacts of agricultural development.

As regards overlaps between the development and own-production pathways, as discussed above, the nutritional impacts of economic development tend to be greater in economies with greater relative importance of the agricultural sector. There is then a larger share of the workforce working in agriculture and getting a double benefit as both producers and consumers from increases in real incomes and in access to improved diets.

Turning now to consider the market pathway for agricultural impacts on nutrition, we focus on two main mechanisms by which this operates: changes in food prices and in food composition, noting first that if these changes are to be driven by changes in domestic agriculture then this requires that food markets are not dominated by imports.

Evidence on the impacts of short term falls in food prices has been discussed earlier to some extent under evidence of impacts via the development pathway. Further evidence of short term impacts is provided by examination of the negative impacts of food price rises. As discussed earlier, initial estimates of very large and damaging increases in the incidence of under nourishment and hunger following the 2008 global food price spike (for example FAO, 2011; de Hoyos and Medvedev, 2011; Ivanic and Martin, 2008; Tiwari and Zaman, 2010) have been moderated by taking into account the countervailing effects of economic growth and income increases benefiting poor people mainly in Asia (FAO et al., 2012; Headey, 2011b) but also to a limited extent in sub Saharan Africa (Verpoorten et al., 2012). Medium term damaging effects of higher food prices on the urban poor are universally recognised, but there is more debate on the effects of higher food prices on the rural poor. Some argue that the rural poor gain long term benefits from higher food prices stimulating increased production and labour demand. Others, however, argue that the evidence for this is limited and that there are a number of structural constraints and considerations that make this unlikely for most poor rural people, particularly in Africa (Dorward, 2012).

There is also some evidence of the negative effects of food price rises on nutritional status. Compton et al. (2010) reviewing studies up to 2010 report that “high food prices increased malnutrition (especially in young children)”. Earlier studies of the effects of high rice prices also found increased malnutrition rates as a result of the impacts of the

Asian crisis in Indonesia (Block et al., 2004)⁸, while Torlesse et al. (2003) report a negative correlation between rice prices and nutritional status in Bangladesh.

Changes in the dietary composition of food may result from changes in the mix of foods available and accessed by consumers or by changes in the nutrient composition of particular foods. An example of improved food intake by consumers is the growth in the market demand for and consumption of orange flesh sweet potato and hence of vitamin A in rural Mozambique following its introduction to and cultivation by smallholder farmers (Westby et al., n.d. cited by Hawkes and Ruel, 2012). Hawkes and Ruel (2012) cite a number of other examples of 'nutrition value chain' interventions promoting increased crop diversity in production and in consumer food intake, in both developing and developed economies.

Evidence on agricultural interventions' impacts on nutrition via the 'own-production pathway' has been the subject of two recent systematic reviews (Girard et al., 2012; Masset et al., 2012). The two studies come to similar conclusions that the evidence base is too weak to draw any robust conclusions regarding the nutritional impacts on producers of the limited number of agricultural interventions investigated. Weaknesses in evidence arose as a result of poor study designs with limited counter-factuals, small sample sizes, and heterogeneous use of variables for measuring nutrition (including measures of dietary changes but relatively few measures of nutritional outcomes). Both studies report promising indications and examples of agricultural interventions impacting on nutritional status, but both conclude that more and better quality studies are needed. It should also be noted, however, that own-production nutritional impacts may be very nuanced and easily missed or over-stated, as illustrated by Behrman et al. (1997) who observe that the timing of extra income to poor labourers in Pakistan determined its impact on calorie intake – with income at planting having an effect (with an elasticity of 0.61) but not at the food abundant harvest stage. It should also be noted these reviews did not cover agricultural interventions undertaken without specific nutritional objectives but whose nutritional impacts were subsequently examined. Likely selection bias poses difficulties both for studies examining specific interventions and for any review of such studies. Nevertheless informative examples of such studies exist and more systematic examination of them could be instructive - particularly with regard to the own-production pathway (Ward and Santos (2010), for example, report significantly reduced stunting in households that received subsidised agricultural inputs in Malawi from 2001 to 2003), but possibly for the market pathway as well.

In this context a review by Hawkes et al. (2012) is helpful in identifying gaps in current and planned research on agriculture for nutrition. They identify the majority of ongoing agriculture nutrition linkage research projects focussing on interventions implicitly or explicitly operating within the own-production pathway (although they do not use this terminology). They also identified a number of poorly researched areas relevant to this

⁸ Also Headey et al. (2012) note that increases in rice prices may lead to households reducing consumption of important micro-nutrients but not of calories as they try to maintain calorie consumption by reallocating spending to a less diverse diet with a higher proportion of staples.

paper and addressed by only a limited number of (or no) projects: whole supply and nutrition impact chains and policy influences on them; the 'development pathway'; the 'market pathway'; governance, policy processes and political economy influences; and cost effectiveness and development of research and evaluation methods and metrics. They did not, however, attempt to assess the quality of the research projects reviewed.

5. What agricultural interventions can promote improved nutrition health and achievement of the MDGs in least developed countries?

In this section we build on earlier discussion and the work of other authors to identify strategic principles, practical principles and practical options for 'nutrition-sensitive agriculture', agricultural interventions aiming to promote improved nutrition.

The discussion of the different pathways in section 3 and of evidence of their impacts in section 4 suggests some broad patterns and strategic principles. We note here that the effectiveness of agricultural development in promoting improved nutrition is generally highest in poorer agrarian economies, and declines with development, as does the proportion of agricultural workers and rural inhabitants. This suggests declining importance of the development and own-production pathways. The importance of the market pathway, on the other hand, is likely to increase with development, as food buyers and purchases increase and subsistence production and consumption decline. Referring back to figure 6, these patterns suggest that agri-nutrition interventions in the least developed, poor agrarian economies are likely to be most effective if they work in the overlap of the development and own-production pathways (intersection C). As development proceeds then the focus should shift more towards areas A and D, before concentrating on the market pathway. In the consequent shift towards the market pathway and away from the own-production pathway, however, there are still likely to be some disadvantaged producers who merit specific attention through own-production pathways, as well as poor consumers whose nutrition could benefit from some engagement in own production of particular foods (such as vegetables, fruit or small livestock). Agri-nutrition interventions will also need to be supported and complemented by other services and interventions and a supportive environment, as shown in figure 6 (though the particular elements needing attention will vary). This pattern of changing pathways has parallels with changing roles for governments in promoting agriculture as proposed by Dorward et al. (2004) (establishing the basics, kick starting markets, facilitating markets) and in promoting agricultural nutrition links as proposed by Paarlberg (2011), with provision of core public goods in 'stage one' (energy and nutrient deficient) countries, targeted service delivery in stage two (energy sufficient but nutrient deficient) countries, and private sector regulation in 'stage three' (excessive calorie) countries.

It must also be recognised that as important players in the value chain, producers' interests will be important in any intervention that seeks to change agricultural practices, even if improvement of their nutrition is not an objective driving that intervention.

These broad strategic principles are supported by and match with more practical principles for nutrition sensitive agriculture. Hawkes and Ruel, 2012 outline nine principles for what they term a nutrition value chain approach – an approach with wider

relevance which is by no means restricted to interventions within the market pathway (as almost all agricultural development involves markets, even if nutrition objectives are not pursued through food markets). The following principles are suggested (Hawkes and Ruel, 2012, pages 35 to 38) :

1. Start with explicit nutrition goals.
2. Clearly define the nutrition problem.
3. Create and capture value for nutrition.
4. Be expansive in the search for solutions, but tailor to context.
5. Focus on the functioning and coordination of the whole chain in order to create sustainable solutions.
6. Add value not only for nutrition (and consumers), but also for other chain actors.
7. Take a broader view of adding value for producers and consumers.
8. Focus on meeting, growing, and creating demand.
9. Create a policy environment in which better nutrition is valued.

Herforth et al., 2012 also suggest principles for nutrition sensitive agriculture, in their case focussing on guiding principles for operational investments that prioritise nutrition in agriculture and rural development. While reiterating the first of Hawkes' and Ruel's principles, they also suggest the targeting of nutritionally vulnerable groups, investment in women, and a focus on increasing all year access to diverse, nutrient-dense foods. They also argue for creation of enabling environments for good nutrition through knowledge and incentives for staff, and active search for opportunities to work across sectors. These latter points suggest the need for the active involvement of different specialists in agriculture, nutrition and other development sectors, and the need for new cross-sectoral thinking and disciplines in addressing these issues.

Fan et al., 2011 provide helpful suggestions on a wider set of principles concerned with the promotion of beneficial linkages of both health and nutrition with agriculture. These are summarised in Box 1. These are particularly useful in also emphasising the importance of feedbacks from nutrition to agriculture and health: these feedbacks have not been a focus of this paper but are nevertheless important.

Finally, we consider practical options for nutrition sensitive agriculture. Figure 5 provides some examples of the types of agricultural intervention that may be useful in nutrition sensitive agriculture. Hawkes and Ruel, 2012 again provide a useful outline of five 'categories of action' within the value chain approach they espouse: information and education for behaviour change; research and technology change (for example through breeding, genetic modification, fertilisation, or agronomy to increase production or change product composition); organisational change, within and among organisations, to promote coordination or change power relations; changes in costs and incentives (through new systems or public or private investments); and development of policies and standards (such as procurement policies and systems or market or food-safety standards). To these might be added, from a wider perspective, changes in national policies (for example on trade, input or product subsidies).

Box 1. Principles and actions for promoting beneficial linkages of health and nutrition with agriculture

Fan et al., 2011

Fill the Knowledge Gaps

- Learn more about how different patterns of agricultural growth affect nutrition and health.
- Invest in research, evaluation, and education systems capable of integrating information from all three sectors.
- Fill the gap in governance knowledge at the global, national, and community levels.

Do No Harm

- Mitigate the health risks posed by agriculture along the value chain.
- Design health and nutrition interventions that contribute to the productivity of agricultural labor.
- Look carefully at the downstream effects of subsidies for production or consumption on consumers' nutrition and health.

Seek Out and Scale Up Innovative Solutions

- Scale up successful interventions.
- Design agriculture, nutrition, and health programs with cross-sectoral benefits.
- Incorporate nutrition into value chains for food products.
- Use all available levers for change.
- Increase consumers' nutrition literacy and highlight the consequences of dietary choices.

Create an Environment in Which Cooperation Can Thrive

- Focus on partnerships among agriculture, nutrition, and health.
- Develop mutual accountability mechanisms among the three sectors.
- Correct market failures.
- Use communication and advocacy to bring about change.

We now briefly discuss an issue that is raised in figure 5 but has not yet been considered, food contamination, focussing on specific mycotoxin contamination . We focus here on aflatoxin and fumonisin, particularly the former. Aflatoxin, more widely known and studied, is produced by *Aspergillus flavus* and *A. parasiticus* infecting maize grain, through insect attack in the field and/or in poor storage conditions. High concentrations of toxins are found in maize, for example in southern, eastern and west Africa. The effects of high concentrations in inducing liver cancer have long been recognised, but there is a growing body of evidence of the importance of other effects from persistent exposure, specifically immune system disorders and stunted growth. These effects are particularly important in poor populations where maize is a staple food often produced under stress and then stored in poor conditions (groundnuts, rice, dried cassava, and sorghum, and millet are also affected). They are also particularly serious in the first 1000 days of life. Given the widespread consumption of (particularly) maize and of poor storage and the high incidence of communicable diseases to which mycotoxins may suppress immunity, food contamination by these mycotoxins is a major issue and one where there are strong links between agriculture and nutrition. Possible measures to reduce infection by *Aspergillus* spp and/or concentrations of these mycotoxins include improved crop pest control,

changes in storage practices to reduce insect infestation / damage and moisture content, infection of grain with competing and harmless fungal species, rejection of affected grain, mineral or yeast based binder additives, market standards and regulations. Interventions must however take account of the poverty and food insecurity of many affected households, the importance of dispersed and informal markets with small transactions in areas with very poor market infrastructure, and the importance of subsistence production and consumption which never enters the market (Gong et al., 2004; J.H. Williams et al., 2012; Wu and Tritscher, 2011; J.H. Williams et al., 2004; Turner et al., 2003; Egal et al., 2005; Khlangwiset et al., 2011).

6. Conclusions

Our review of agriculture- nutrition linkages and achievement of the MDGs in least developed countries has shown how achievement of the nutrition related MDGs is unlikely in large populations of poor people mainly in South Asia and Sub Saharan Africa. There are strong conceptual linkages between agricultural development and nutrition improvements which may be categorised into three main pathways (the development, own production and market pathways). The evidence on the efficacy of these pathways is mixed with some strong and some weak or negative impacts, as a result of varied processes and contexts as well as of insufficient high quality empirical research investigating these linkages. It is clear, however, that there should be significant potential for improving the nutritional status of poor people through a range of agricultural interventions alongside complementary social and nutritional interventions – with particular attention to the status of women.

We conclude with a brief discussion of the major challenges to implementing agricultural interventions to achieve improved nutrition outcome. These may be broadly categorised into challenges facing coordinated action in agriculture for nutrition, those facing the achievement of required improvements in agricultural production and food security, and challenges in translating agricultural improvements into nutritional improvement.

As regards coordinated action in agriculture for nutrition, a number of challenges are implicitly set out in our earlier discussion of principles for nutrition value chain approaches, for nutrition sensitive agriculture and for the promotion of linkages of health and nutrition with agriculture. The fundamental challenges here are in working effectively across traditionally separate disciplines and sectors which are enshrined in often competing bureaucratic structures in governments, research organisations, and other agencies; in different bodies of knowledge and world views; in different career and incentive structures for staff; and in sectoral funding allocations (see for example Benson, 2011; von Braun et al., 2011). There are therefore major challenges in getting policy and political commitment to bridge the two disciplines and sectors at all levels of work from policy formulation and implementation to field operations. These challenges need to be specifically addressed initially with a search for clear ‘win-win’ opportunities across the divides (such as local sourcing for school feeding schemes) and with ‘policy champions’, ‘Civil Society Advocacy Coalitions’ and Community and Other Decentralized Efforts as suggested by Benson (2011). Box 1 provides a detailed list of other relevant recommendations. An underlying difficulty is the lack of sufficient good quality research

on agriculture - nutrition interactions and the lack of common metrics across the disciplinary and sectoral interfaces. Another core challenge is the achievement of greater gender empowerment – women play critical roles in agriculture and the integrated management of household resources for nutrition (as well as other goals).

Challenges in increasing agricultural production and improving food security have become increasingly apparent since the 2008 food spike, which results from a ‘perfect storm’ of interacting factors – involving declining or stagnant productivity (as a result of low investment, increasing environmental pressures and increasing fossil fuel costs) , increasing demand (from rising incomes and populations) and increasing instability (from environmental shocks, reduced stocks, and financial and physical speculation) (see for example Godfray et al., 2010; Headey and Fan, 2010; Piesse and Thirtle, 2009; FAO, 2009) . Further rises in fossil fuels, the negative effects of climate change on agricultural and continuing population and dietary change with growing incomes pose further challenges to agricultural labour productivity and prices, particularly in poorer agrarian economies in the tropics – with both a general tightening of availability and prices (affecting access to food) and increasing instability (again in both availability and market access). Unfortunately these challenges strike at all three agriculture – nutrition pathways (See figures 3 to 5). Addressing them requires approaches that again cross disciplines and sectors in building resilience, diversity and nutritional effectiveness (Naylor, 2011).

Finally, and drawing together the two previous sets of challenges, there are challenges in getting agricultural development to actually impact nutrition. These challenges arise for multiple reasons (and are well illustrated by the nutritional challenges in India) – for example the lack of gender empowerment in agricultural fora, challenges in getting changes in food security systems that impact the critical ‘thousand days’ from conception, or limits to benefits from biofortification of staples where infants do not consume enough to get sufficient nutrient benefits even after biofortification.

The challenges of improving agricultural –nutrition linkages to address the scandal of acute under nutrition are therefore very substantial. There is, however, considerable potential for gain with emerging new opportunities and, even with a marked lack of attention in the past, a strong record of achievement to build on. There is much to play for.

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