

Can reductions in agricultural food losses avoid some of the trade-offs involved when safeguarding domestic food security?

A case study of the Middle East and North Africa

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Abstract:

Using the MAGNET model we find that stimulating agricultural growth by tackling food losses in the Middle East and North Africa outperforms manufacturing and service-led growth in terms of enhancing food security, reducing dependence on and vulnerability to changes in the world food market, and decreasing rural poverty. Whereas trade-offs occur in terms of production and employment in different sectors, this policy is potentially more beneficial by avoiding fiscal consequences of tax or subsidy policies. Costs associated with measures to reduce food losses may counteract beneficial impacts and should be avoided as much as possible.

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INTRODUCTION

All countries in the world battle with the question of how best to promote growth and prosperity for the wider population. Recently, in view of the food price peaks of 2007-2008 and 2011-2012, the debate is shifting towards the question of how to feed the world population (FAO, 2009a), and especially the poor and vulnerable (see, for example, Ivanic and Martin, 2008). The numbers suggest that globally, compared to 2009, 70 per cent more food would have to be produced to satisfy the needs of a population growing by a third in 2050, which could be met by increased investments (of around 50 per cent) in agriculture and rural development, by promoting technological change and productivity growth and improved access to food via a competitive, fair and reliable global trading system (FAO, 2009a).

Many of the policy instruments that are available to countries to safeguard food security are costly and so are likely to involve trade-offs (Von Braun, 2008; Von Braun et al., 2008; World Bank, 2008; FAO, 2011a; Fan, Torero and Heady, 2011; Benson et al., 2013). This is true for investments in agriculture and related sectors, infrastructure and social protection programs which have to be paid for and may go at a cost of other pressing needs, for example education and health. It is also the case for policies of lowering taxes (for example consumption taxes, import tariffs) and/or increasing subsidies (for example consumer or producer subsidies), for cereals or other food commodities, which generally lower government revenues and/or increase government expenditures.

Depending on the policy measure taken, trade-offs may occur between net beneficiaries and net payers, including rich versus poor populations, urban versus rural populations, or net food producers versus consumers. In the area of trade policies, for example, net food importing countries have limited fiscal leeway to reduce import tariffs so as to prevent domestic food prices from rising, a policy which benefits net food consumers but hurts net food producers (Bouët and Laborde Debucquet, 2012; Martin and Anderson, 2012; Rutten, Shutes and Meijerink, 2013).

Some of the cost and resulting trade-offs may be avoided by focusing on measures that reduce resource inefficiencies, particularly losses and waste, occurring in the various stages of the food supply chain from farm to fork. Evidence suggests that close to one third of the edible parts of food produced for human consumption, gets lost or wasted globally, equivalent to around 1.3 billion tonnes per year (FAO, 2011b). In medium and high income countries these losses, termed ‘waste’, occur mostly at the end of the food chain (retail and final

consumption), whereas in low-income countries, the losses mostly occur in production, postharvest and processing stages (Parfitt, Barthel and MacNaughton, 2011).

If these losses and waste are avoidable¹, reducing them offers a window of opportunity for quick wins in terms of enhancing food security, since some of the measures that need to be taken may not be costly and could be implemented fairly easily, thereby avoiding some of the usual trade-offs involved. Examples are improved skills and knowledge of farmers leading to improved farming practices regarding the planting, growing and harvesting of crops, and increasing the understanding and awareness of consumers when it comes to food waste, labelling and food storage. Other measures, such as investments in infrastructure, storage, transport and distribution, are likely to require substantial funds. It is unclear, however, how much this is relative to the potential welfare gains through lower prices for consumers and lower costs and/or higher sales for producers.

We investigate the issue of food losses in the Middle East and North Africa (MENA) region, where rising food prices in the end of 2010 sparked a wave of civilian protests and subsequent demands for democratic and economic reforms, known as the Arab Spring.

This study specifically compares three alternative policies and their impacts in MENA, focussing on outcomes in terms of economic growth, changes in (agri-food) production and prices, employment and wage impacts, impacts on households' food security and poverty. The policies include a policy of reducing import tariffs, a policy of stimulating a manufacturing and service-led growth agenda, and a policy of reducing food losses in the supply of primary (agricultural) commodities in particular. These policy scenarios are implemented in a global economic simulation model, MAGNET, for the period 2010 to 2020, and relative to a baseline scenario in which world food prices are rising (modelled via an increase in world cereal prices).

The analysis is novel in two main respects. The first contribution is in the modelling of the impacts of reducing food losses in agricultural supply via technology shocks. This has not been done before, to our knowledge, and can easily be replicated for other countries and regions in the world. We further place this in the context of basic economic theory of markets, used to cast light on the expected impacts of reducing food losses on producers, consumers and overall welfare. The second contribution is that we provide further insight into whether manufacturing and service-led growth rather than agriculture-led growth is better to tackle food insecurity and poverty in MENA, as suggested by a recent study of the International

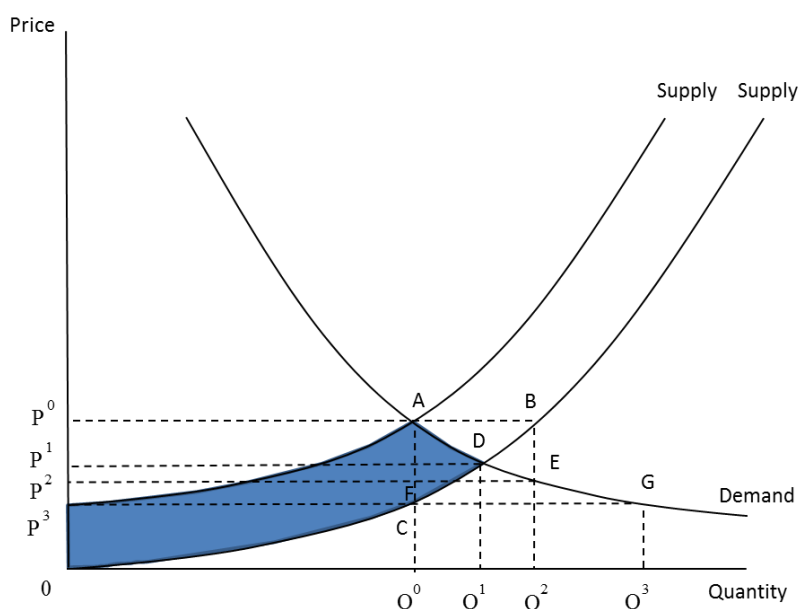
Food Policy Research Institute (Breisinger et al., 2012) and in contrast with the general food security literature (see also, for example, FAO, WFP and IFAD, 2012). Results are useful for policy makers and other stakeholders interested in the issue of how to reduce vulnerability and food insecurity of populations in view of the trade-offs involved.

The remainder of the article is structured as follows. The next section presents some theory regarding the potential impacts of reducing food losses. The third section discusses the MAGNET model and the data used. Subsequent sections discuss, respectively, the scenario set-up and the results. The final section presents the main conclusions and policy implications.

THE ECONOMIC IMPACTS OF REDUCING FOOD LOSSES: A GRAPHICAL EXPOSITION

In this section we examine the economic impacts of (reducing) food losses in a low-dimension partial equilibrium analysis.² The expected impacts of reducing food losses using standard economic theory can best be explained via simple diagrams. Figure 1 depicts the market for a food commodity³, with a standard upward sloping supply curve and a standard downward sloping demand curve. The price mechanism ensures that demand equals supply. The equilibrium is reached at point *A*, where the price is P^0 and the quantity traded is Q^0 .

FIGURE 1. THE IMPACTS OF REDUCING FOOD LOSSES ON THE SUPPLY SIDE



Let us assume that there are losses in the production and supply of this food commodity. In such a situation, the socially optimal supply curve, or the supply curve of this food commodity that would not have these losses, lies below the original supply curve, as depicted by *Supply'* in Figure 1; given the original price, P^0 , more can actually be produced and supplied to the market (Q^2 at point B), or the original quantity, Q^0 , can actually be produced at a much lower cost (P^3 at point C) if losses were to be absent.⁴

Avoiding these losses, given the original demand curve, would thus result in a lower price, P^1 , and a higher equilibrium quantity, Q^1 , in the market, as given by point D . At this new equilibrium consumers can buy more food at a lower price, resulting in a welfare gain to consumers as measured by the change in the consumers surplus of P^0ADP^1 . Similarly, producers can sell more, but at a lower price, resulting in a change in the producer surplus of $P^1DQ^0 - P^0AP^3$, which is also positive. The overall welfare gain equals the sum of the change in the producer and the consumer surplus, which amounts to the area P^3ADQ^0 , the blue shaded area between the new and old supply curve and under the demand curve.

The outcome and so the size of the welfare effects depends on the slope of the demand and supply curves. Assuming that the extent of losses is the same as before (i.e. the shift in the supply curve is of the same distance as before) and independent of scale and/or price we can distinguish the following cases (see Rutten, 2013). In the presence of a perfectly inelastic (i.e. vertical) demand curve, the new equilibrium is at point C , with consumers receiving all the gains from reducing food losses in the form of a lower price and a welfare gain of P^0ACP^3 .⁵ In the presence of a perfectly elastic (i.e. horizontal) demand curve, avoiding food losses in supply results in a new equilibrium at point B , where all the gains translate into an increase in the equilibrium quantity supplied and demanded. This results in a welfare gain to producers of P^3ABQ^0 . Similarly, if supply is perfectly inelastic (vertical supply curve), the equilibrium is at point E , resulting in a lower equilibrium price and higher equilibrium quantity compared to the analysis before. Consumers gain by P^0AEP^2 , but producers here lose out by $FEQ^2Q^0 - P^0AFP^2$. The overall welfare result, however, is positive (area AEQ^2Q^0). Finally, a completely elastic (horizontal) supply curve results in an equilibrium at point G , whereby demand increases the most (to Q^3) as the price falls the most (to P^3) and all welfare gains end up with the consumers who benefit to the maximum extent possible, by area P^0AGP^3 .

In this simple, low-dimension diagrammatic analysis, overall welfare, and specifically the welfare of consumers, generally goes up, whereas that of producers could go down, namely in

the case of supply being relatively inelastic. This is an interesting finding as it suggests that producers of food commodities such as crops, which in the short-run have a relatively inelastic supply curve given the time it takes before it is ready to be harvested, may be worse off (in the short-run) when tackling food losses. In the long-run, supply of agricultural commodities is almost perfectly elastic, so then welfare gains are likely to occur (and most, if not all, of these end up with the consumer).⁶

We have, however, made various simplifying assumptions to come to our findings. Firstly, we assume throughout the analysis that all losses in the production and supply of this food commodity are avoidable, that they are independent of scale (and price) and that they are costless to diminish. In reality this may well be different so that the outcomes may differ. Specifically, the impacts may be much smaller if only a part of the food losses is avoidable, and the net welfare gains will be lower if there are costs involved. These costs will have a price increasing and quantity reducing effect in the market for the food commodity in question, counteracting the original shift down (or to the right) that occurs when reducing food losses in supply. Moreover, if losses increase with scale (and price), the observed impacts of reducing food losses will be greater if the market is of a reasonable size (i.e. the quantity demanded and supplied is large) and the price is high; and vice versa, if losses decrease with scale (and price), impacts of reducing losses will be bigger if the market is small and the price is low.⁷

Another simplification is that we ignore where the losses occur in the supply chain (intermediate inputs, factor inputs), and that we abstract from interactions with other markets and actors. Our analysis makes the usual *ceteris paribus* assumption, i.e. that all else remains the same, which is highly unlikely. For example, reducing losses generally results in a lower price, which could increase demand elsewhere in the system, potentially leading to second-order effects. An example is wheat becoming cheaper if losses in production and supply fall, as a result of which meat demand may go up (as meat will become cheaper to produce due to lower intermediate input costs of using wheat). Similarly biofuel use may go up. Another example is that households may waste more if food becomes cheaper, counteracting the positive impact of reducing food losses on the supply side.⁸

What exactly will happen remains an empirical question and is best investigated in an applied model of the whole economy with added real-life complexities. Nevertheless, these effects will still operate in the background and thus give a useful guide to the interpretation of the outcomes of such a model.

EMPIRICAL MODEL AND DATA

For the empirical analyses in this paper we employ the global economic simulation model, MAGNET. MAGNET (Modular Applied GeNeral Equilibrium Tool) is a multi-region Computable General Equilibrium (CGE) model that has been widely used to simulate the impacts of agricultural, trade, land and biofuel policies on global economic development and vice versa.⁹ MAGNET is based on the Global Trade Analysis Project (GTAP) model but can be extended in various directions in a modular fashion, depending on the policy questions at hand.

The GTAP core model accounts for the behaviour of households, firms and the government in the global economy and how they interact in markets (Hertel, 2007). In line with other CGE models, the GTAP model incorporates profit and utility maximisation behaviour of producers and consumers, perfectly competitive markets which clear via price adjustments, constant returns to scale in production, and the Armington assumption in trade which differentiates domestic and imported goods by origin. In contrast with other CGE models, the GTAP model has been constructed around a ‘representative regional household’, which collects all income that is generated in the economy (both from the employment of endowments as well as from various (net) taxes) and allocates it over private household and government expenditures on commodities and savings for investment goods. With all markets in equilibrium, firms earning zero profits and households being on their budget constraint, global savings must equal global investments. The latter are computed on a global basis, via a ‘global bank’ which assembles savings and disburses investments, so that all savers in the model face a common price for this savings commodity. Global savings determine global investments, i.e. the macro closure is savings driven and essentially neoclassical in nature. Since the CGE model can only determine relative prices, the GDP deflator is set as the numéraire of the model, against which all other prices are benchmarked. Changes in prices resulting from the model simulations thus constitute real price changes.

For the purpose of this study, MAGNET, compared to GTAP, has been extended in four directions. Firstly, MAGNET employs a more sophisticated production structure, accounting for the inherent difference in the ease of substitution between land and non-land factors of production in value added. Secondly, the model adopts a more sophisticated consumption structure, allowing for a better depiction of changes in diets observed over time, away from staple foods and towards more nutritious foods.¹⁰ The third extension incorporates segmented

labour and capital markets, which allows for differences in factor remunerations between agricultural and non-agricultural sectors.¹¹ The final extension improves the modelling of land supply, allowing for land supplied to agriculture to respond to a land rental rate instead of being exogenously fixed as in GTAP.¹²

MAGNET has been calibrated using the GTAP v8 with base year 2007. Given the focus of this paper, we distinguish 11 countries and/or regions, 17 sectors and five factors of production (Table 1). Next to our main region of interest, MENA, we distinguish the remaining regions by geographical aggregates, including EU and Rest of Europe, North America, Central and South America, Oceania, Asia, and Sub Saharan Africa. With respect to sectors, we distinguish nine primary agricultural sectors (sectors 1 to 9 in Table 1, including fishing) and seven processed food categories (sectors 10 to 16 in Table 1) that have strong links with the aforementioned primary sectors. We aggregate the remaining sectors into a manufacturing and services category. The model retains the standard GTAP specification of five factors of production, including skilled and unskilled labour, capital, land and natural resources.

TABLE 1. MAGNET MODEL CLASSIFICATIONS

Countries and regions		Sectors		Production factors
1. MENA	Middle East and North Africa	1. CER	Paddy rice, wheat and other cereal grains	1. Land
2. EU27	EU27	2. V_F	Vegetables and fruits	2. Unskilled labour
3. ROE	Rest of Europe	3. OSD	Oil seeds	3. Skilled labour
4. NAM	USA, Canada and rest of North America	4. C_B	Sugar cane, sugar beet	4. Capital
5. CSA	Central and South America	5. OCR	Other crops	5. Natural resources
6. OCE	Australia, New Zealand and rest of Oceania	6. CTL	Cattle, sheep, goats and horses	
7. ASIA	Asia	7. OAP	Other animals and products (swine, poultry, eggs, wool,...)	
8. SSA	Sub-Saharan Africa	8. RMK	Raw milk	
		9. FSH	Fishing	
		10. CMT	Cattle meat products: cattle, sheep, goats, horse	
		11. OMT	Other meat products	
		12. VOF	Vegetable oils and fats	
		13. MIL	Dairy products	
		14. PCR	Processed rice	
		15. SGR	Sugar	
		16. FBT	Other food, beverage and tobacco products	
		17. M_S	Manufacturing and services	

SCENARIO SET-UP

Since GTAP is essentially static in nature, investments not adding to the productive capacity of industries, projections into the future are obtained in MAGNET by allowing the exogenous

factor endowments and the productivity of these factors, most notably yields, to grow according to a specific growth path. We project the global economy from 2007 up to 2012 and then forward up to 2020.

The point of departure for our scenario analysis is a baseline, ‘Business as Usual’ (BaU) scenario which serves as the benchmark scenario to which alternative ‘what if’ scenarios containing exogenous shocks and/or policy changes can be compared. The baseline scenario projects the (global) economy forward, assuming a continuation of past trends and no implementation of new policies. Most importantly, GDP and population growth are taken from USDA (2012), which assumes a return towards long-run steady growth following after the global recession and financial crisis, and decreasing population growth across the world with the exception of Sub-Saharan Africa. Labour supply follows the growth path of population, whereas capital follows that of GDP ensuring that the capital-output ratio is roughly constant over time, as we generally observe. Land productivity (i.e. yield) projections are derived from the IMAGE (Integrated Model to Assess the Global Environment) model and based upon FAO projections up to 2030 (Bruinsma, 2003). Technological progress is assumed to be mainly labour saving and faster in manufacturing (and then agriculture) relative to services.¹³

We then proceed with simulating an increase in the world price for cereals (WCP scenario), which is modeled via a harvest failure in North America and Rest of Europe. The increase in the world price of cereals over the period 2012 to 2020 that we implement is one that may hypothetically happen in the long-term; the model is only suited to do long-run analyses and so cannot address issues related to the recently observed extreme food price volatility. With North America and Rest of Europe together accounting for over 25 per cent of global cereal production, such a scenario set-up will lead to a rise in the world cereal prices and will affect MENA (only) via the channel of trade since imports of cereals will become more expensive.¹⁴ We assume that cereal yields in North America and Rest of Europe fall by an extreme amount of 50 per cent due to harvest failure. As a result, the world price (PW) for cereals increases by 5.9 percentage points (pp)¹⁵ relative to the BaU, which is quite substantial and is comparable to the average annual growth rate of the cereal prices of the last decade.¹⁶ This price increase is felt throughout the world through the channel of trade, resulting in higher producer and consumer prices. Specifically, with import prices for cereals rising, domestic consumers substitute away from imported cereals towards domestic cereals, resulting in increases in the domestic consumer price (PPD) for cereals of 2.1pp in MENA, relative to the BaU.

We model three policy responses of MENA to the rising world price and domestic consumer prices for cereals and so food. Firstly, governments of MENA countries could, as net cereal and food importing countries, lower import tariffs so that cereal prices faced by households do not rise and any potential civil unrest is avoided (Safeguarding domestic Food Security, SFS, scenario). Such measures have been taken by some MENA countries in the past (FAO, 2009b). The import tariff reduction on cereals in MENA required to stabilise the domestic consumer price of cereals faced by households to pre-world price increase levels is 14pp.

The second scenario is an Agricultural Food Losses (AFL) scenario, focusing on reducing food losses by improving efficiency in agricultural production and post-harvest handling and storage in MENA. Consistent evidence on food losses and waste is hard to come by, let alone in the region of our interest. A recent study by FAO (2011b) assesses the losses that occur along the entire food chain and identifies the underlying causes and ways to prevent them. It does this for all regions in the world, including North Africa, West and Central Asia. Applying the waste percentages in agricultural production and postharvest handling and storage, to the primary agricultural commodities (including fishing) identified in Table 1, results in the loss percentages shown in Table 2.¹⁷ Loss percentages seem especially high in vegetables, fruits and other crops that have a highly perishable nature, followed by oil seeds.

TABLE 2. LOSSES IN AGRICULTURAL SUPPLY (% OF PRODUCTION)

Commodity/sector		Agricultural production	Postharvest handling and storage	Total losses in agricultural supply
1. CER	Cereals	6	8	14
2. V_F	Vegetables and fruits	20	10	30
3. OSD	Oil seeds	18	6	24
4. C_B	Sugar cane, sugar beet	6	10	16
5. OCR	Other crops	20	10	30
6. CTL	Cattle, sheep, goats and horses	7	0	7
7. OAP	Other animals and products	7	0	7
8. RMK	Raw milk	4	6	10
9. FSH	Fishing	7	5	12

Source: adapted from FAO (2011b). Notes: Other crops inherit the loss percentages of vegetables and fruits, which may slightly overstate the extent of losses. Sugar cane and beet is allocated the loss percentage of roots and tubers. Cattle and other animals and products inherit the loss percentages of meat.

We incorporate the total loss percentages (Table 2, last column), as total factor productivity shocks in the agricultural and fishing sectors of MENA over 2012-2020. This implies that, given all inputs into production, outputs of these sectors may be increased, or, given outputs,

the use of all inputs into the production of these sectors may be reduced, implying a rise in productivity by the shown percentages.¹⁸ The model determines the optimal input-output mix, whereby losses on both input and output side will be reduced. This is over and above technological change in the baseline.

As indicated in the theory section, food losses may well have underlying causes, e.g. vary with scale or price, not all of it may be avoided, and reducing food losses may involve costs. In the absence of consistent and reliable evidence on this,¹⁹ we take the extent of food losses as given, assume that all of it is avoidable, and focus on the impacts that arise when we reduce them. The outcomes represent maximum impacts and provide boundary values for how much reducing food losses may cost for it to be worthwhile from an economic perspective. For example, if the price of cereals falls by x% following a reduction in food losses, then the unit cost of reducing food losses in cereals should not exceed this value.

Thirdly, governments of MENA could pursue manufacturing and service-led growth so as to counter the negative impacts of rising food prices (MSG scenario). We implement total factor productivity (TFP) change in the manufacturing and services sector such that the same annual growth as in the second scenario (AFL) is achieved (4.5 per cent per year). As in the second scenario, this is manna from heaven. The resulting impacts should be interpreted as extreme outcomes in terms of what investments so as to induce growth in manufacturing and services may effectuate and may cost for them to be worthwhile from an economic perspective. The scenario assumptions are summarised in Table 3.

TABLE 3. SUMMARY OF SCENARIO ASSUMPTIONS

Driver\ Scenario	Business as Usual (BaU)	BaU plus rising World Cereal Prices (WCP)	Safeguarding domestic food security (SFS) through import tariff reductions in response to WCP	Agricultural growth targeting food losses (AFL) in response to WCP	Manufacturing and service-led growth (MSG) in response to WCP
Demographics	Population trends as observed in past	Same as BaU	Same as BaU	Same as BaU	Same as BaU
Macro-economic growth	Growth in line with past trends but taking into account negative effect of global slowdown	Declining cereal yields increase world cereal prices, hurting net food importing MENA	Negative growth impacts in MENA fall, though consumers benefit at a cost of producers and the government	Negative growth impacts in MENA are reduced by agriculture-led growth	Negative growth impacts in MENA are reduced by manufacturing and service-led growth
Crop yields	Yield growth as observed in past	Same as BaU	Same as BaU	Same as BaU	Same as BaU
Technological change	Continuous trends in labour saving technological progress; technological progress is fastest in manufacturing, followed by agriculture, and then services	Same as BaU	Same as BaU	Technological progress in BaU plus total factor productivity growth in primary agriculture targeting food losses in production and post-harvest handling and storage in MENA	Total Factor Productivity (TFP) growth in manufacturing and services generating same growth as in AFL in MENA

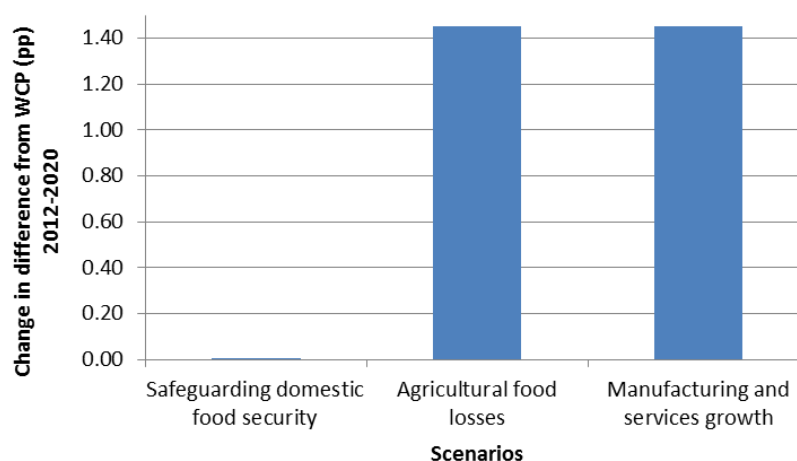
RESULTS

The main output of MAGNET is a set of socio-economic indicators that describe the development of the economy of the MENA region for the period 2012-2020 and the interaction with other regions. In view of the focus of this paper on food security, we report the outcomes of the scenario analysis in terms of the following indicators: GDP, production and prices, employment and wages, households' food security as measured by household consumption of food (determined by household income and the market price for food paid by households) and poverty (on the basis of developments in agricultural unskilled wages relative to the price of cereals). The results are reported relative to a baseline in which world food (cereal) prices are rising (WCP scenario), and are expressed in percentage points (pp) for the period 2012-2020, unless stated otherwise. Below, we will discuss the impact of our scenarios on each of these indicators.

(a) Economic growth impacts

Effects on economic growth are evident only in the MENA region (Figure 2). Specifically, GDP growth in the MENA region is stimulated in the second and the third scenario (AFL and MSC respectively), but it hardly changes in the first scenario (SFS). Responding to higher world cereal prices by lowering import tariffs merely is a defensive strategy to protect consumers and on its own does not promote growth of the economy of the MENA region. A better, proactive strategy to stimulate the economy and protect domestic consumers in the long-term is to implement policies that enhance growth. It should be noted that the effects of the AFL and MSG scenario are of the same magnitude because both scenarios generate the same TFP growth.

FIGURE 2. GDP GROWTH IMPACTS IN MENA

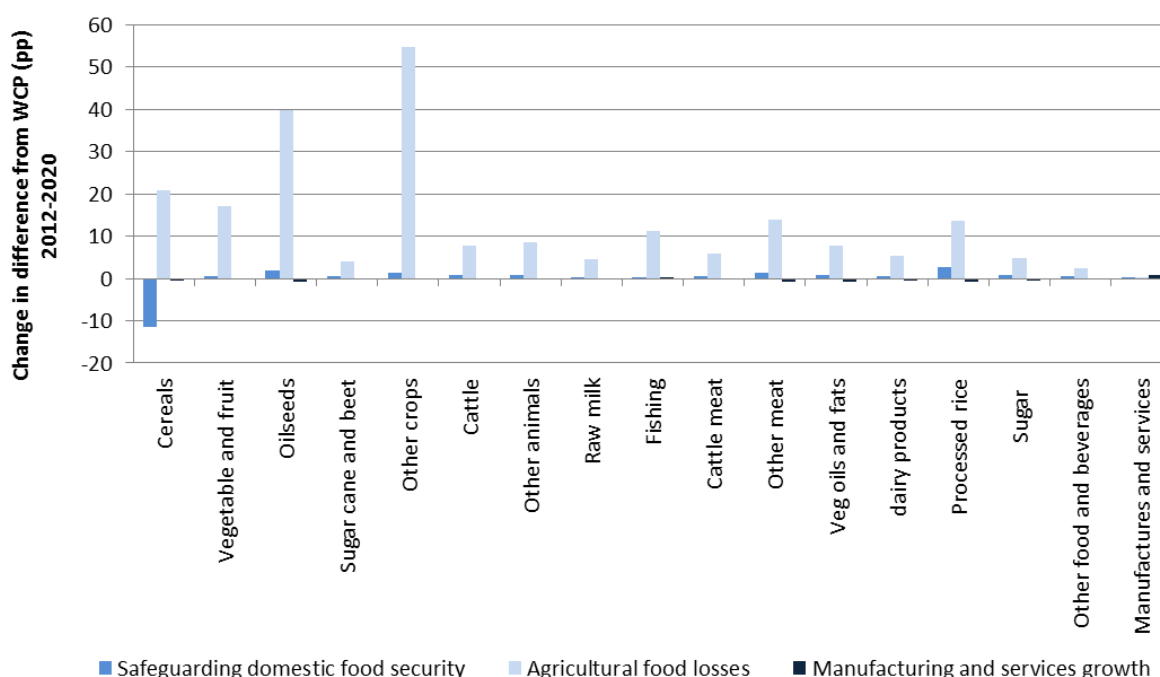


Source: MAGNET simulations

(b) Sectoral impacts

The impacts of the three scenarios on production differ across sectors (Figure 3). By nature the SFS and AFL scenarios affect the agri-food sectors relatively more, whereas the MSG scenario has most impact on the manufacturing and services sector, at a cost of agri-food sectors.

FIGURE 3. IMPACTS ON PRODUCTION IN MENA



Source: MAGNET simulations

In the SFS scenario, the import tariff reduction on cereals so as to protect domestic consumers leads to increased competition from abroad, resulting in a lower production of this sector of 11.5pp and a fall in the producer price of 2.1pp. This has a positive impact on all other sectors, but notably agri-food sectors. Primary agricultural sectors benefit as land prices fall, on average by 8.1pp (due to the fall in demand for land used in cereals), and feed (from cereals) is becoming cheaper, resulting in lower unit costs of production and so lower prices, which fall on average by 1.3pp. The sectors that benefit most of these developments are the oil seeds sector, expanding by 1.9pp, and the other crop sector, expanding by 1.3pp. Processed food sectors also benefit, notably processed rice which increases production by 2.7pp, for which cereals are an important intermediate input into production, and other meat, expanding by 1.4pp, using cereal as feed.

In the AFL scenario, agricultural growth targeting food losses in supply results in much lower production costs for primary agricultural sectors, due to improved efficiency in the use of all inputs, including land (land prices are, for example, shown to fall by 12.6pp). This benefits all primary agricultural sectors which now expand, including cereals, and by a lot more than in the first scenario. Production prices for vegetables and fruits, other crops and oil seeds are shown to fall the most, by 23.4pp, 21.2pp and 17.8pp respectively. These sectors experience

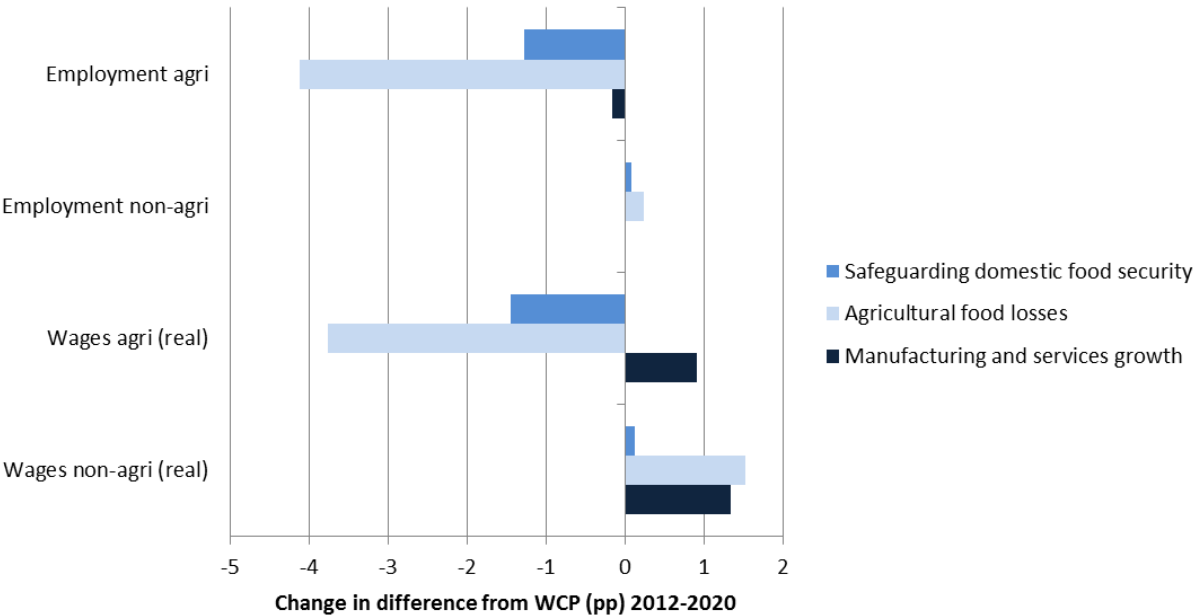
the biggest losses in agricultural supply and so experience the biggest gains if these were to be reduced (see Table 2). Production of vegetables and fruits, other crops and oil seeds expand by 17pp, 54.8pp and 39.7pp respectively. The increase in the production of vegetables and fruit is lower than this of other crops, due to the fact that this sector is bigger in size.

In the MSG scenario, the same growth as in the AFL scenario is targeted towards the manufacturing and services sector only, drawing resources out of the agri-food sectors, but with impacts on these sectors that are spread out and so hardly visible. Specifically, the manufacturing and service sector grows by 0.9pp (this is a relatively small number as this sector comprises over 90 per cent of the value of output generated in MENA).

(c) Labour market impacts

Labour market impacts follow the observed changes in production at the sectoral level and, as a result, they are mostly felt under the AFL scenario which also had the biggest impact on sectoral production (Figure 4).

FIGURE 4. LABOUR MARKET IMPACTS IN MENA



Source: MAGNET simulations. Note: agri contains all primary agricultural sectors (including fishing). Non-agri includes the remaining sectors (manufacturing and services and all processed foods).

In the SFS scenario employment in agriculture and so real agricultural wages decline (by 1.27pp and 1.45pp respectively) due to the contraction of the cereals sector, to the benefit of

non-agricultural sectors where employment and real wages rise slightly (by 0.08pp and 0.13pp respectively).

In the AFL scenario, increased efficiency due to lower wastage in primary agricultural sectors implies less labour is needed to produce the same level of output. As a result employment in agriculture and so real wages fall (by 4.12pp and 3.78pp respectively) to the benefit of non-agricultural sectors where employment and real wages rise (by 0.24pp and 1.52pp respectively).

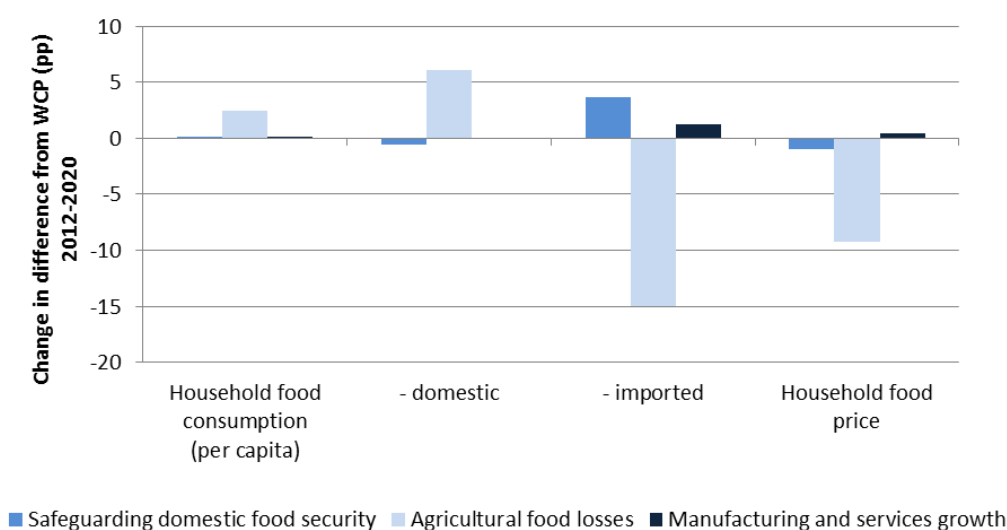
In the MSG scenario, the total factor productivity growth, which initially saves labour boosts production so much that employment slightly improves (by 0.01pp) at a cost of employment in primary agricultural sectors (falls by 0.16pp). As a result real wages in both agricultural and non-agricultural sectors rise (by 0.9pp and 1.3pp respectively). The observed effects are similar across skilled and unskilled labour and have therefore not been reported separately by labour type.

(d) Food security and poverty impacts

Income, as measured by GDP per capita, increases in the MENA region in the AFL and MSG scenarios, in line with the development of GDP growth, discussed before. The SFS scenario hardly affects income as it generates very limited economic growth in MENA.

Figure 5 shows the impacts on food security indicators, namely on per capita household food consumption, in total and from imports and domestic sources, and food prices paid by households.

FIGURE 5. IMPACTS ON FOOD SECURITY INDICATORS IN MENA



Source: MAGNET simulations. Note: The food bundle refers to all agri-food commodities consumed by households, including all primary sectors, fishing and all processed food sectors, which are weighted according to their household budget shares.

The results show that due to a policy of safeguarding domestic food security via lowering import tariffs on cereals (SFG scenario), household food consumption slightly improves due the fall in prices. However, household consumption of domestic food decreases (by 0.6pp) and is replaced by imported food items (increase of consumption by 3.7pp) and in particular of cereals, as these become relatively cheap due to the fall in import tariffs on cereals. As a result, the share of imported cereals in total cereal consumption increases by almost 17pp in 2020.

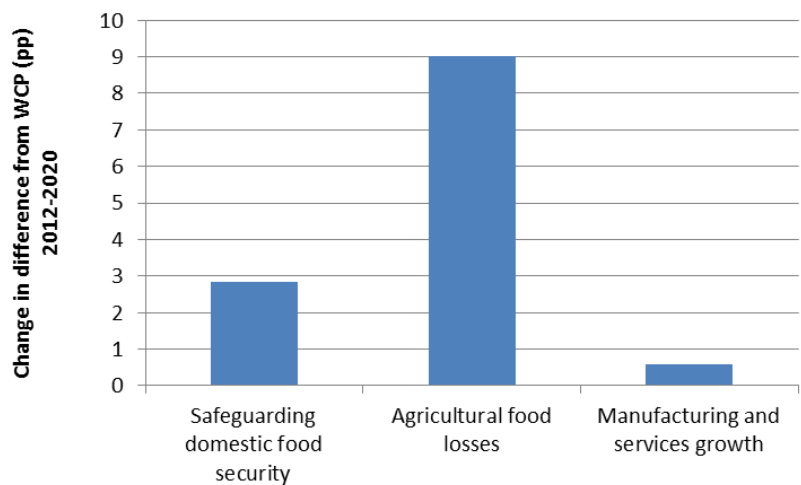
As shown in Figure 5, household food consumption increases the most in the AFL scenario (by 2.4pp) and this is mostly because more domestic foods are consumed (increase by 6pp) compared to imported ones (decrease by nearly 15pp). Improving the productivity of the agricultural sector by avoiding losses results in lower consumer prices (fall by 9pp), which greatly enhances food security in the MENA region. In contrast with the previous scenario, households depend less on food imports and are thus less vulnerable to changes in world market prices.

The effects of the MSG scenario on food security are rather limited because the income growth is now attributable to the manufacturing and services sector, lowering its prices to the benefit of household consumption. Food consumption, however, is hardly affected. The increase in household food consumption (by 0.2pp) stems more from imported food items

(increase by 1.2pp), whereas households overall pay a slightly higher price for food (increase by 0.4pp).²⁰

Changes in food security are a particular concern for rural households who, with respect to their income depend on food prices, but with respect to expenditures also, with food consumption being determined by how the impacts on income (via wages) and expenditures (via prices) balance out. Figure 6 shows the impacts on the wages of unskilled labour relative to cereal prices in each of the scenarios. Given that relatively more unskilled labour is employed in rural areas for agricultural production with lower wages than for skilled labour and that cereals are the main staple food item in rural areas, this ratio can be used as a poverty indicator. A positive change of the ratio (which is displayed in Figure 6) over time and compared to a reference situation implies lower poverty, while a negative change denotes higher poverty.

FIGURE 6. IMPACTS ON RURAL UNSKILLED WAGES RELATIVE TO CEREAL PRICES



Source: MAGNET simulations

The results show that all three scenarios imply lower poverty (positive change of the ratio). Poverty declines the most in the AFL scenario where, despite the largest decrease in wages for the rural unskilled, cereal prices fall by more, leaving households better off when it comes to their purchasing power of food items.

Safeguarding domestic food security (SFS scenario) does not lower poverty as much as avoiding food losses by improving agricultural productivity (AFL scenario) because the

decrease in cereal prices is not as high. This is despite the lower decrease in rural unskilled wages.

Last but not least, enhancing manufacturing and services growth (MSG) lowers poverty the least. This scenario increases mainly skilled labour wages which also drives upwards the wage of unskilled labour but at a lower pace. The wage increase is however sufficient to compensate for the increase in cereal prices (also seen in Figure 5, for the whole food basket). This outcome confirms the general expectation that poverty falls as the economy grows and manufacturing and services sectors become relatively more productive.

CONCLUSIONS AND POLICY IMPLICATIONS

This paper has looked into the issue of whether avoiding food losses in the MENA region benefits food security and can avoid some of the trade-offs involved compared to two other policies of lowering import tariffs or pursuing a manufacturing and service-led growth agenda in a world where world food prices are rising.

From a diagrammatic analysis of the impacts of reducing food losses in supply we learn that avoiding food losses generally leads to a higher equilibrium quantity produced and consumed, at a lower cost and price, with welfare gains for producers, consumers, and in total. The analysis shows that inter-temporal effects play a role and that the results are highly depending on how much of the losses are avoidable, the underlying causes and the costs involved when reducing losses.

From an applied analysis using the MAGNET model, we find that, firstly, protecting domestic consumers from higher world food prices via lowering import tariffs is merely a defensive strategy and so does not perform well in terms of enhancing economic growth, compared to policies that explicitly aim to generate growth, whether in agriculture or in manufacturing and services. Secondly, trade-offs occur depending on the targeted sectors or actors. Specifically, a policy of protecting domestic consumers against rising world food prices will benefit consumers but harm producers of the commodity in question, whereby producers in other sectors of the economy will also benefit. In contrast, a policy of promoting agricultural growth targeted at reducing food losses or a policy of manufacturing and service-led growth will benefit agricultural, respectively manufacturing and services, sectors much more, at a cost of other sectors. Thirdly, trade-offs are also visible when it comes to labour market impacts. Specifically, employment and real wages in agriculture fall to the benefit of non-

agricultural sectors when consumers are protected from rising world prices via import tariffs or when agricultural food losses are reduced via technological progress. A policy of manufacturing and service-led growth has the same effect, but with real wages rising everywhere as due to the subsequent boost in demand more labour is drawn from agriculture as well. Fourthly, in terms of food security, whereas all policies enhance overall food security, protecting domestic consumers from rising world food prices via lowering import tariffs increases the dependence on and so vulnerability to changes in the world food market (in particular price volatility). Growth which targets food losses in agriculture has the opposite effect, and has a much bigger positive impact on food security. Manufacturing and service-led growth leads to a limited positive impact on food security, and mainly in terms of imports rather than domestic goods, so increasing vulnerability to changes in the world market. Fifthly, poverty, measured in terms of the development of wages of the rural poor relative to the price of staple foods, falls in all three scenarios, but most when agricultural food losses are tackled, since food prices as a consequence fall relatively more than wages do. They fall the least in terms of manufacturing and service led-growth as this benefits mostly skilled labour wages (in manufacturing and services), with the wage increase of unskilled rural labour being insufficient to compensate for the rise in the price of staple foods.

From the perspective of both food security and poverty we thus find that policies promoting agricultural growth perform better than policies targeting manufacturing and service-led growth, even if they lead to the same overall economic growth. Furthermore, the impacts of the former policies may potentially be bigger than that of lowering import tariffs as relatively more gains are to be made in reducing losses, given the limited (fiscal) leeway to reduce import tariffs. The same may be true for other tax or subsidy instruments that also have budgetary implications.

Given the lack of data on the costs of measures to tackle losses and the extent to which these losses are avoidable, the outcomes should be interpreted as maximum impacts and act as an upper bound on potential costs. Further research should look into these issues and should aim to model the underlying causes of food losses, rather than taking them as given. Policies should focus on those measures that involve the least costs, including improved farm practices. Future analysis is also foreseen in the areas of modelling the impacts of reducing food losses and waste throughout the supply chain from farm to fork, including processing, distribution and final consumption stages, and in the rest of the world.

ENDNOTES

¹ ‘Avoidable’ is often interpreted as ‘edible’ as non-edible food losses or waste are not destined for human consumption.

² This section is in its entirety based on ideas developed by Rutten (2013). Presented here is a reduced version of this paper. It forms the basis of the applied modelling in the following sections, which can distinguish different types of food commodities and their interrelations in the food supply chain from farm to fork and within the broader (global) economy.

³ While this paper considers the economic impacts of food losses, the issue of losses, or more broadly, resource inefficiencies, is not only confined to food but is also applicable elsewhere. This analysis can therefore be extended to other non-food commodities.

⁴ Note that the ‘optimal’ supply curve doesn’t necessarily have to be parallel to the original supply curve, as the extent of losses may vary with the scale of production (and price). We abstract from this for ease of exposition.

⁵ For most staple foods, demand will be fairly inelastic. For other foods, e.g. more luxurious types of food such as fish and red meat, this is not the case and elasticities will be much higher.

⁶ This finding also suggests the importance of inter-temporal effects, not addressed in this simple low-dimension partial equilibrium framework.

⁷ Note that in the former (latter) situation, the supply curve with and without losses would increasingly diverge from one another as the quantity and price increases (decreases).

⁸ Of course, consumers under pressure from prevailing morale may also display the opposite behaviour and reduce food waste.

⁹ For recent applications with the MAGNET model, see Banse et al. (2011), Neumann et al. (2011), Prins et al. (2011), Rutten, Van Rooij and Van Dijk, 2012), Rutten, Shutes and Meijerink (2013).

¹⁰ This approach has been documented in Verburg et al. (2008).

¹¹ This approach originates from Hertel and Keeney (2005). As in GTAP, natural resources and land are assumed to adjust sluggishly between sectors.

¹² This approach has been documented in Eickhout et al. (2008).

¹³ This is consistent with more pessimistic views about the future of agricultural productivity as represented by predictions of stable or even rising real agricultural prices in the future.

¹⁴ The North America and Rest of Europe regions together account for close to 65 per cent of MENA’s cereal imports at market prices, higher than any other region in our model. This makes these regions highly suitable candidates for simulating a harvest failure for the mere purpose of causing a significant change in the world price for cereals with a substantial impact on the MENA region.

¹⁵ Percentage points (pp) measure the difference between two percentages, specifically the percentage change in a certain variable in a scenario of interest minus the percentage change in that same variable in the reference scenario, here the BaU scenario.

¹⁶ According to the World Bank, the average annual growth rate of cereal prices (in real terms) during 2000-2010 was about five per cent (World Bank, 2012).

¹⁷ Since the focus is on losses in agricultural supply, this excludes losses in processing and packaging (which would affect processing industries, not primary agricultural sectors), losses in distribution (which would affect transport) and losses (i.e. waste) occurring on the demand side (household or retail).

¹⁸ We don’t know in fact if losses occur in the use of certain factor or intermediate inputs and so implicitly assume that it is the same for all.

¹⁹ While Kader et al. (2012) report on various measures that need to be taken in the various segments of the supply chain for the different agricultural commodities where food losses occur, this study doesn’t provide an estimate of the costs involved. An estimate of costs is in any case hard to get for sectors as a whole, at the country level or at the regional level (for MENA), as measures are generally applied locally and for a specific commodity and circumstances may well differ at the local and regional level, even within one country.

²⁰ Note that, despite the changes in the consumption of imported food, the net trade status of the MENA region does not change (MENA remains a net importer of cereals and animal-based products) and the sources of imports also remains the same. Specifically, the EU-27 and North and Central and South America remain the main cereal exporters to MENA (trade shares of 29 per cent, 22 per cent and 25 per cent in 2020 respectively), Oceania and the EU-27 each account for about 33 per cent of MENA’s dairy imports in 2020, whereas Central and South America is the region with the largest share in beef and sheep meat exports of MENA (about 42% in 2020).

REFERENCES

- Banse, M., Van Meijl, H., Tabeau, A., Woltjer, G., Hellmann, F. and Verburg, P.H. (2011) Impact of EU Biofuel Policies on World Agricultural Production and Land Use. *Biomass and Bioenergy*, Vol. 35, No.6, pp. 2385-2390.
- Benson, T., Minot, N., Pender, J., Robles, M. and von Braun, J. (2013) Information to Guide Policy Responses to Higher Global Food Prices: The Data and Analyses Required, *Food Policy*, Vol. 38, pp. 47-58.
- Bouët, A. and Laborde Debucquet, D. (2012) Food Crisis and Export Taxation: The Cost of Non-Cooperative Trade Policies, *Review of World Economics*, Vol. 148, No.1, pp. 209-233.
- Breisinger, C., Ecker, O., Al-Riffai, P. and Yu, B. (2012). *Beyond the Arab Awakening: Policies and Investments for Poverty Reduction and Food Security*, Food Policy Report, Washington DC: IFPRI.
- Bruinsma, J. (ed) (2003) *World agriculture: Towards 2015/30, FAO Perspective*, London: Earthscan and Rome: FAO.
- Eickhout, B., Van Meijl, H., Tabeau, A. and Stehfest, E., (2008) The Impact of Environmental and Climate Constraints on Global food Supply. Chapter 9 in T. Hertel, S. Rose, and R. Tol (eds), *Economic Analysis of Land Use in Global Climate Change Policy*. Routledge, USA, in press.
- Fan, S., Torero, M. and Heady, D. (2011) Urgent Action Needed to Prevent Recurrent Food Crises, IFPRI Policy Brief 16, March 2011.
- Food and Agricultural Organization (2009a) How to Feed the World in 2050, Issues brief, High Level Expert Forum: How to Feed the World in 2050, 12-13 October 2009, Rome, Italy.
- Food and Agricultural Organization (2009b) Policy Measures Taken by Governments to Reduce the Impact of Soaring Prices (As of 15 December 2008), FAO. Available from <http://www.fao.org/giews/english/policy/1.asp>.
- Food and Agricultural Organization (2011a) Guide for Policy and Programmatic Actions at Country Level to Address High Food Prices, FAO's Initiative on Soaring Food Prices.
- Food and Agricultural Organization (2011b) *Global Food Losses and Food Waste: Extent, Causes and Prevention*, Study conducted for the International Congress SAVE FOOD! at Interpack 2011, Düsseldorf, Germany.
- FAO, WFP and IFAD (2012) *The State of Food Insecurity in the World 2012: Economic Growth Is Necessary But Not Sufficient to Accelerate Reduction of Hunger and Malnutrition*, Rome: FAO.
- Hertel, T.W. (ed) (1997) *Global Trade Analysis: Modelling and applications*, Cambridge: Cambridge University Press.
- Hertel, T.W. and Keeney R. (2005) Assessing the Impacts of WTO Reforms on World Agricultural Markets: A New Approach, in A. Sarris and D. Hallam (eds) *Agricultural Commodity Markets and Trade: New Approaches to Analyzing Market Structure and Instability*, Rome: FAO.
- Ivanic and Martin, W. (2008) Implications of Higher Global Food Prices for Poverty in Low-Income Countries, *Agricultural Economics*, Vol. 39 (supplement s1), pp. 405-416.

- Martin, W. and Anderson, K. (2012) Export Restrictions and Price Insulation During Commodity Price Booms, *American Journal of Agricultural Economics*, Vol. 94, No. 2, pp. 422-427.
- Kader, A. A., Kitinoja, L., Hussein, A. M., Abdin, O., Jabarin, A. and Sidahmed, A. E. (2012) Role of Agro-industry in Reducing Food Losses in the Middle East and North Africa. Agro industry and Infrastructure, FAO, Regional Office for the Near East, Cairo, Egypt February.
- Neumann, K., Verburg, P.H., Elbersen, B.S., Stehfest, E. and Woltjer, G.B. (2011) Multi-Scale Scenarios of Spatial-Temporal Dynamics in the European Livestock Sector, *Agriculture, Ecosystems and Environment*, Vol. 140, No. 1-2, pp. 88-101.
- Parfitt, J., Barthel, M. and MacNaughton, S. (2011) Food Waste Within Food Supply Chains: Quantification and Potential for Change to 2050, *Phil. Trans. R. Soc. B*, Vol. 365, No. 1554, pp. 3065-3081.
- Prins, A.G., Eickhout, B., Banse, M., Van Meijl, H., Rienks, W. and Woltjer, G. (2011) Global Impacts of European Agricultural and Biofuel Policies, *Ecology and Society*, Vol. 16, No. 1, art. 49.
- Rutten, M. (2013) The Economic Impacts of (Reducing) Food Waste and Losses: A Graphical Exposition. Wageningen School of Social Sciences Working Paper No. 7, February 26 2013.
- Rutten, M., Shutes, L. and Meijerink, G. (2013) Sit Down at the Ballgame: How Trade Barriers Make the World Less Food Secure, *Food Policy*, Vol. 38, pp. 1-10.
- Rutten, M., Van Rooij, W. and Van Dijk, M. (2012) Global-to-Local Modelling of Land Use Dynamics in Vietnam: Potential Effects of a High Climate Impact and High Economic Growth Scenario. GTAP Resource 3799.
- Verburg, R., Woltjer, G., Tabeau, A., Eickhout, B. and Stehfest, E. (2008) Agricultural Trade Liberalisation and Greenhouse gas Emissions: A Simulation Study Using the GTAP-IMAGE Modelling Framework, Report 3.08.02, The Hague: LEI Wageningen UR.
- Von Braun, J. (2008) Rising food prices: What Should Be Done?, IFPRI Policy Brief, April 2008.
- Von Braun, J., Ahmed, A., Asenso_Okyere, K., Fan, S., Gulati, A., Hoddinot, J., Pandya-Lorch, R., Rosegrant, M.W., Ruel, M., Torero, M., Van Rheenen, T. and von Grebmer, K. (2008) High Food Prices: The What, Who, and How of Proposed Policy Actions, IFPRI Policy Brief, May 2008.
- USDA (2012) International Macroeconomic Dataset. Economic Research Service, United States Department of Agriculture. Available from <http://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx>.
- World Bank (2012) Historical Data on commodity prices. Available from <http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/0,,contentMDK:21574907~menuPK:7859231~pagePK:64165401~piPK:64165026~theSitePK:476883,00.html>.
- World Bank (2008) Rising Food Prices: Policy Options and World Bank Response, Paper Prepared as Background to the Meetings of the Development Committee, April 2008.