Reducing food losses to protect domestic food security in the Middle East and North Africa

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Abstract

Food security policies are usually costly and involve trade-offs. We investigated this issue by simulating three policy responses to rising world food prices, using the MAGNET model applied to the Middle East and North Africa. A policy of tackling agricultural food losses increases food consumption at lower costs and prices, with welfare gains forming an upper bound of the costs of tackling agricultural food losses. Whilst trade-offs occur as resources are drawn from elsewhere, they outperform a policy of reducing import tariffs by boosting agricultural and overall growth much more. This leads to a reduced rather than increased import dependency, and higher welfare gains. A policy of stimulating equal-sized economic growth via manufacturing and services does worse regarding food prices, consumption and import dependency, but generates slightly higher welfare gains. Given their potential to improve food security, measures to tackle food losses in agriculture should focus on cost-effective solutions.

Key words: food losses and waste; food security; scenario analysis; computable general equilibrium modelling; Middle East and North Africa

1. Introduction: Policies to improve food security and trade-offs involved

The food price peaks of 2008 and 2012, and increasing challenges arising from climate change, socio-economic development and population growth, have placed the issue of food security, both now and in the future, high on the policy agenda. Many of the policy instruments that are available to countries to safeguard food security are costly and therefore involve trade-offs (Von Braun 2008; Von Braun *et al*. 2008; World Bank 2008; Fan *et al*. 2011; FAO 2011a; Benson *et al*. 2013). This is true for investments in agriculture and related sectors that have to be paid for and may go at the expense of other pressing needs. It is also the case for policies of lowering taxes and/or increasing subsidies for agri-food commodities, which generally lower government revenues and/or increase government expenditures.

However, some of the costs and 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. Evidence suggests that close to one third of the edible parts of food produced for human consumption is lost or wasted globally, equivalent to around 1.3 billion tons per year (FAO 2011b). In low-income countries, so-called food losses in edible food mass destined for human consumption occur mainly in the agricultural production, post-harvest and processing stages (over 40% in the latter two stages), whereas in medium- and high-income countries they occur mostly at the retail and final consumption level (over 40%), and are termed 'food waste' (Parfitt *et al*. 2011). If these food losses and waste were avoidable, reducing them offers a window of opportunity for quick wins in terms of enhancing food security (HLPE 2014), since some of the measures to reduce them may not be costly and could be implemented fairly easily, thereby avoiding the usual trade-offs involved. We investigated this issue in the Middle East and North Africa (MENA) region, where rising food prices at the end of 2010 sparked a wave of civilian protests and subsequent demands for democratic and economic reforms, known as the Arab Spring. Specifically, we compared three alternative policies in reaction to rising food prices and their medium- to long-term impacts in MENA, focusing on outcomes in terms of economic growth, changes in (agri-food) production and prices, and impacts on households' food security, poverty and welfare. The policies include reducing import tariffs, stimulating a manufacturing and service-led growth agenda, and reducing food losses in the supply of primary (agricultural) commodities. These policy scenarios were implemented in the global economic simulation model MAGNET (Woltjer & Kuiper 2014) for the period 2012 to 2020, and relative to a baseline scenario in which world food prices are rising.

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 productivity shocks with an application to MENA. This method, capturing the nature of food losses as essentially representing an efficiency problem, has previously been applied by Rutten and Verma (2015), but with a focus on Ghana. We further placed this in the context of the basic economic theory of markets, which was used to cast light on the expected welfare impacts. The welfare gains resulting from the model can be interpreted as an upper bound on the costs that could be used to foot the bill for undertaking agricultural food loss reductions in MENA. The second contribution is that we provide further insight into whether manufacturing and service-led growth, rather than agriculture-led growth, is more effective in tackling food insecurity and poverty in MENA, as suggested by Breisinger *et al*. (2012), and in contrast with the food security literature (FAO *et al*. 2012).

2. Context: The state of food (in)security and food losses in the MENA region

Countries in the MENA region (Morocco, Oman, Qatar, Saudi Arabia, Tunisia, Turkey, Algeria, Libya, Western Sahara, Iraq, Jordan, Lebanon, Palestine, Syria, Yemen, United Arab Emirates, Bahrain, Egypt, Iran, Israel and Kuwait) are facing severe challenges when it comes to achieving food and nutrition security (defined as "… when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996)). Structural challenges include rapid population growth, urbanisation, low productivity and a limited natural resource base (land and water). Next to these, natural and man-made disasters, including droughts, other climate-related events and, most notably, conflicts and civil unrest (e.g. in Yemen, Iraq, the West Bank and Gaza Strip, and Syria), affect the region particularly badly, increasing the vulnerability of the population to rising and volatile food prices (FAO 2014a).

The evidence provided by the FAO is alarming. The number of chronically undernourished people in the Middle East and North Africa reached 79.4 million in the period from 2010 to 2013, equivalent to 11.2% of the population. This is slightly higher than the number of chronically undernourished in the period from 2008 to 2010, and represents an increase of 28% since the period from 1990 to 1992. Chronic undernourishment amongst children, as measured by the number of stunted children, is estimated at 43.4%. At the same time, nearly 25% of the population is obese, double the world average and close to three times that of developing countries as a whole. Micronutrient deficiencies are on the rise everywhere, and this negatively affects health, school performance and productivity (FAO 2014a). The evidence on the double, or even triple, burden of malnutrition illustrates the diversity between (and within) countries in the region, some belonging to the most affluent countries in the world (e.g. Israel and Kuwait), and some belonging to the most undernourished countries (e.g. Yemen), with within-country inequalities relating to the unequal distribution of income and the associated access to food. An important factor that is said to contribute to the region's vulnerability in terms of food insecurity is the high losses occurring in the early stages of the food supply chain (FAO 2014a). Evidence from the FAO (2011b) suggests that food losses in the stages of agricultural production, post-harvest handling and storage in the region are relatively high (Table 1, data for North Africa, West and Central Asia) and vary by commodity: 6.8% of production for meat, 9.5% for milk, 11.6% for fish and seafood, 14% for cereals, 16% for roots and tubers, 21% for oilseeds and pulses and 27% for fruit and vegetables. A notable outlier in the remainder of the food supply chain is the category of fruit and vegetables (loss or waste varies from 12 to 27%), due to their perishable nature, a trend also observed in other regions of the world (FAO 2011b). Another outlier, perhaps, is the relatively high percentage of waste in the final consumption of cereals (12%), the region's dominant staple food. In the MENA region, as elsewhere, causes for the relatively high food losses lie predominantly in the areas of poor harvesting, storage and transport due to shortfalls in financial, technical and managerial capacities (FAO 2011b; Kader *et al*. 2012).

Table 1. Food losses and waste estimates by commodity and stage of the food supply chain – North Africa, and West and Central Asia (% of production)

Commodity	Agricultural production, post-harvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	14	2.7	4	12
Roots and tubers	16	12	4	6
Oilseeds and pulses	21	8	2	2
Fruits and vegetables	27	20	15	12
Meat	6.8	5	5	8
Fish and seafood	11.6	9	10	4
Milk	9.5	2	8	2

Source: Adapted from FAO (2011b).

The high food losses, in combination with relatively low yields in the MENA region, aggravate the dependence of the region on the world market for meeting its food needs. Given a rapidly increasing population that is, on average, increasingly well off and urbanising, food demand is expected to continue to outstrip food supply, and so MENA's dependence on food imports, currently estimated at around 50%, is expected to rise further (FAO 2014b), with cereals accounting for the majority of that (around 40%) (FAO 2014a). This is a concern, as it makes the region more vulnerable to price changes on the world market. Countries that are able to generate sufficient foreign exchange through exports (i.e. oil-exporting countries) will generally be able to cope, whereas others may not (e.g. Yemen, Lebanon, Jordan) (FAO 2014a). Within countries, the poor, notably rural landless, marginal farmers and urban poor, who spend a relatively large proportion of their household budget on food, will be particularly affected (FAO 2014b).

It would appear that reducing these losses is much less costly than measures that increase imports, production area or yields (Kader *et al*. 2012). However, it is very difficult to assess whether this is the case, since data on costs are lacking. While Kader *et al*. (2012) report on various measures that need to be taken in the food supply chain, they do not provide an estimate of the costs involved.

3. Theory: The economic impacts of reducing food losses

In this section we examine the economic impacts of (reducing) food losses in a low-dimension partial equilibrium analysis. We draw heavily on the framework developed by Rutten (2013), which forms the basis of our empirical analysis.

Figure 1 depicts a market for a food commodity, with a standard upward-sloping supply curve and a standard downward-sloping demand curve, which forms a simplified representation of the full food supply chain. The price mechanism ensures that demand equals supply, reached at equilibrium point A, where the price is P^0 and the quantity traded is Q^0.

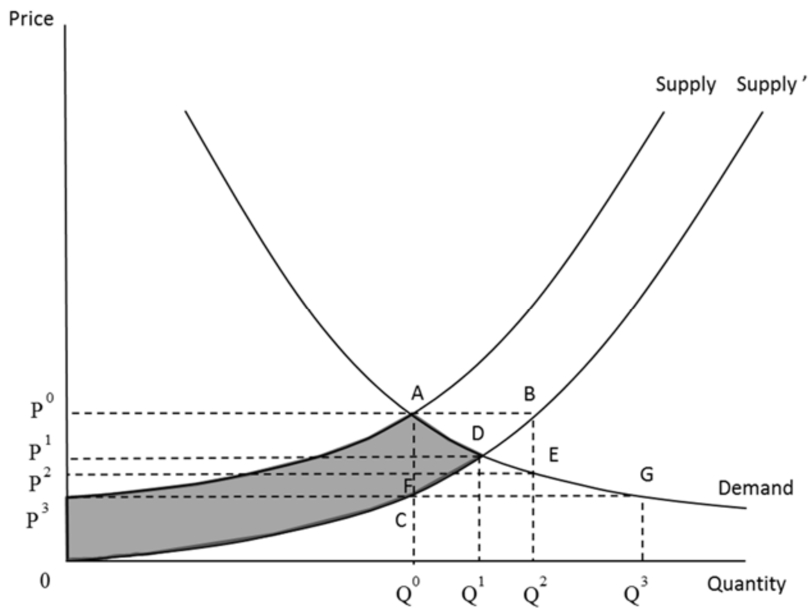

Figure 1: The impacts of reducing food losses on the supply side
Source: Rutten (2013)

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 without these losses, lies below the original supply curve, depicted by $Supply\ '$ in Figure 1; given the original price, P^0, more can be produced and supplied to the market (Q^2 at point B), or the original quantity, Q^0, can be produced at a much lower cost (P^3 at point C) if losses were to be absent. Note that the 'optimal' supply curve does not 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.

Avoiding these losses, given the original demand curve and the motivation for and means of doing so, would 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 ($Q^1 - Q^0$), at a lower price ($P^0 - P^1$), 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 $P^1D0 - P^0AP^3$, 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^3AD0 – the shaded area between the new and old supply curve and under the demand curve.

The outcome, and hence the size, of the welfare effects depend on the slope of the demand and supply curves and various other simplifying assumptions we made to come to our findings, including that all food losses are avoidable, that they are independent of scale (and price), that they are costless to diminish, that we ignore where the losses occur in the supply chain, and that we abstract from interactions with other markets and actors using the *ceteris paribus* assumption (e.g. household demand, demand for feed and fuels). Rutten (2013) provides a thorough discussion of factors of influence and their impacts on the outcomes. 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.

4. MAGNET: An empirical model of the world economy

MAGNET (Modular Applied GeNeral Equilibrium Tool) is a multi-region computable general equilibrium (CGE) based on the Global Trade Analysis Project (GTAP) model and that can be extended in various directions in a modular fashion, depending on the policy questions at hand (Hertel 1997; Woltjer & Kuiper 2014). For the purpose of this study, MAGNET, compared to standard 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. The third extension incorporates segmented labour and capital markets, which allows for differences in factor remunerations between agricultural and non-agricultural sectors. In this setup, labour and capital are perfectly mobile within agricultural and non-agricultural sectors, but move slowly between agricultural and non-agricultural sectors, which leads to rural-urban wage and rent differentials, as observed in reality. 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. MAGNET has been calibrated using the GTAP v. 8 with base year 2007. Given the focus of this paper, we distinguish 11 regions, 17 sectors and five factors of production (Table 2).

Table 2: MAGNET regions, sectors and factors of production

Regions	Sectors	Production factors
Middle East and North Africa	Paddy rice, wheat, other cereal grains	Land
EU27	Vegetables and fruits	Unskilled labour
Rest of Europe	Oil seeds	Skilled labour
USA, Canada and rest of North America	Sugar cane, sugar beet	Capital
Central and South America	Other crops	Natural resources
Australia, New Zealand and rest of Oceania	Cattle, sheep, goats and horses	
Asia	Other animals and products	
Sub-Saharan Africa	Raw milk	
	Fishing	
	Cattle meat products	
	Other meat products	
	Vegetable oils and fats	
	Dairy products	
	Processed rice	
	Sugar	
	Other food, beverage and tobacco products	
	Manufacturing and services	

Next to our main region of interest, MENA, we identified 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 specified nine primary agricultural and seven processed food categories (sectors 1 to 9 and 10 to 16 in Table 2 respectively) that have strong links with the aforementioned primary sectors. We aggregated the remaining sectors into a manufacturing and services category. The model retains the standard GTAP specification of five factors of production.

5. Scenarios: Rising world food prices and three potential policy responses in MENA

The point of departure for our scenario analysis is a 'Business as Usual' (BaU) scenario that 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 the USDA (2012). Land productivity (i.e. yield) projections are derived from IMAGE (Integrated Model to Assess the Global

Environment) 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, consistent with more pessimistic views on the future of agricultural productivity, as represented by predictions of stable or even rising real agricultural prices in the future.

We then proceeded by simulating an increase in the world price for cereals (WCP scenario), which is modelled via a harvest failure in North America and the Rest of Europe. The increase in the world price of cereals over the period 2012 to 2020 that we simulate is one that may hypothetically happen. We assume that cereal yields in North America and the Rest of Europe fall by an extreme amount of 50% due to harvest failure. With North America and the Rest of Europe together accounting for over 25% of global cereal production and close to 65% of MENA's cereal imports at market prices, such a scenario setup leads to a rise in the world cereal prices and affects MENA (only) via trade, since imports of cereals will become more expensive. Specifically, the world price (PW) for cereals increases by 5.9 percentage points (pp) relative to the BaU over 2012 to 2020, which is comparable with the average annual growth rate of cereal prices over the last decade, of around 5% (World Bank 2012). This results in increases in the domestic consumer price (PPD) of cereals of 2.1 pp in MENA, relative to the BaU over the same period.

We modelled three policy responses of MENA to the rising world and domestic consumer prices for cereals, and hence food. Firstly, the governments of MENA countries could, as other 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 (Domestic food price stabilisation, DPS, scenario). Such measures have been taken by some MENA countries in the past (FAO 2009). The import tariff reduction on cereals required in MENA to stabilise the domestic consumer price of cereals faced by households to pre-world price increase levels is 14 pp on average. (Cereal tariffs are bilateral and, for most regions from which MENA imports, already very low and so become subsidies: original tariff levels are 0.5 for Oceania, 10.5 for North America, 14.6 for Central and South America, 18.3 for EU27, 2.8 for Asia, 2.6 for Sub-Saharan Africa and 13.4 for the Rest of Europe).

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. We applied the food loss percentages of FAO (2011b), shown in the first column of Table 1, to our model as productivity shocks in the agricultural and fishing sectors of MENA over 2012 to 2020 by matching them with the sectors identified in Table 2. Since the scenario focuses on the potential of agriculture in contributing to food and nutrition security in the region, only losses in agricultural supply (production and post-harvest handling and storage) were tackled, nonetheless covering the biggest chunk of food losses and waste in the MENA region (slightly over 40% for all agri-food commodities on average). Modelling reductions in food losses via productivity improvements reflects the nature of food losses, essentially representing an efficiency problem. Tackling these food losses, given the inputs into production, increases the outputs of agricultural sectors or, given outputs, reduces the use of inputs into the production of these sectors, implying a rise in productivity by the shown percentages. Since we do not in fact know if losses occur in the use of certain factor or intermediate inputs, and we do not know the nature of the measures taken (data are lacking, section 2), we assume uniform productivity increases (i.e. the shocks are implemented as total factor productivity shocks). The model subsequently determines the optimal input-output mix, whereby losses on both the input and output sides will be reduced. This is over and above technological change in the baseline. As indicated in the theory section, food losses may not all be avoidable and may involve costs. In the absence of consistent and reliable evidence (section 2), we take the extent of losses in agricultural supply as given, assume that all of it is avoidable, and focus on the impacts that arise when we reduce these food losses. The outcomes represent maximum impacts and provide boundary values for how much the tackling of agricultural food losses may cost for it to be worthwhile from a welfare-economic perspective.

Thirdly, the governments of MENA could pursue manufacturing and service-led growth so as to counter the negative impacts of rising food prices (MSG scenario), as also investigated by Breisinger *et al*. (2012). We implemented total factor productivity (TFP) change in the manufacturing and services sector such that the same annual growth as in the second scenario (AFL) was achieved (4.5% per year). As in the second scenario, the resulting impacts should be interpreted as extreme outcomes in terms of what investments to induce growth in manufacturing and services may bring about and what it may cost for them to be worthwhile from a welfare-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)	Domestic food price stabilisation (DPS) 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, although consumers benefit at the 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 AFL in MENA

A final note regarding the comparability of the scenarios is in order. Strictly speaking, the DPS and AFL scenarios are not comparable. Food price rises most often concern cereal prices. When stabilising domestic food price rises caused by cereal price rises it thus is natural to look at cereal prices only, i.e. to stabilise the source (DPS scenario). In order to show the potential that tackling food losses has in terms of lowering food prices, we included all commodities (AFL scenario), since losses do not occur only in cereals. In order to induce strict comparability between the two scenarios, we could have focused on cereal loss reductions only, but then we would have focused on only one agricultural sector, which would render a comparison with a broad-based manufacturing and service-led growth (MSG) scenario useless and would allow us to address food security concerns only partially. In terms of outcomes, the pattern or direction of effects would be the same in the case of tackling cereal losses only, although impacts will be less pronounced, as in the AFL scenario.

6. Results: Growth, production, food security, poverty and welfare impacts

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 to 2020, unless stated otherwise.

6.1 Economic growth

Effects on economic growth are evident only in the MENA region. Specifically, GDP growth in the MENA region is stimulated in the second and third scenario (AFL and MSG respectively) by 1.5 pp over and above growth in the baseline, but it hardly changes in the first scenario (DPS). 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 the growth of the economy of the MENA region. A better, proactive strategy to stimulate the economy and protect domestic consumers in the long term would be to implement policies that enhance growth. It should be noted that the effects of the AFL and MSG scenarios are of the same magnitude because both scenarios are set up to generate the same TFP growth.

6.2 Production and prices

The impacts of the three scenarios on production differ across sectors (Figure 2). By their nature, the DPS and AFL scenarios affect the agri-food sectors relatively more, whereas the MSG scenario has the greatest impact on the manufacturing and services sector, at the cost of agri-food sectors.

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

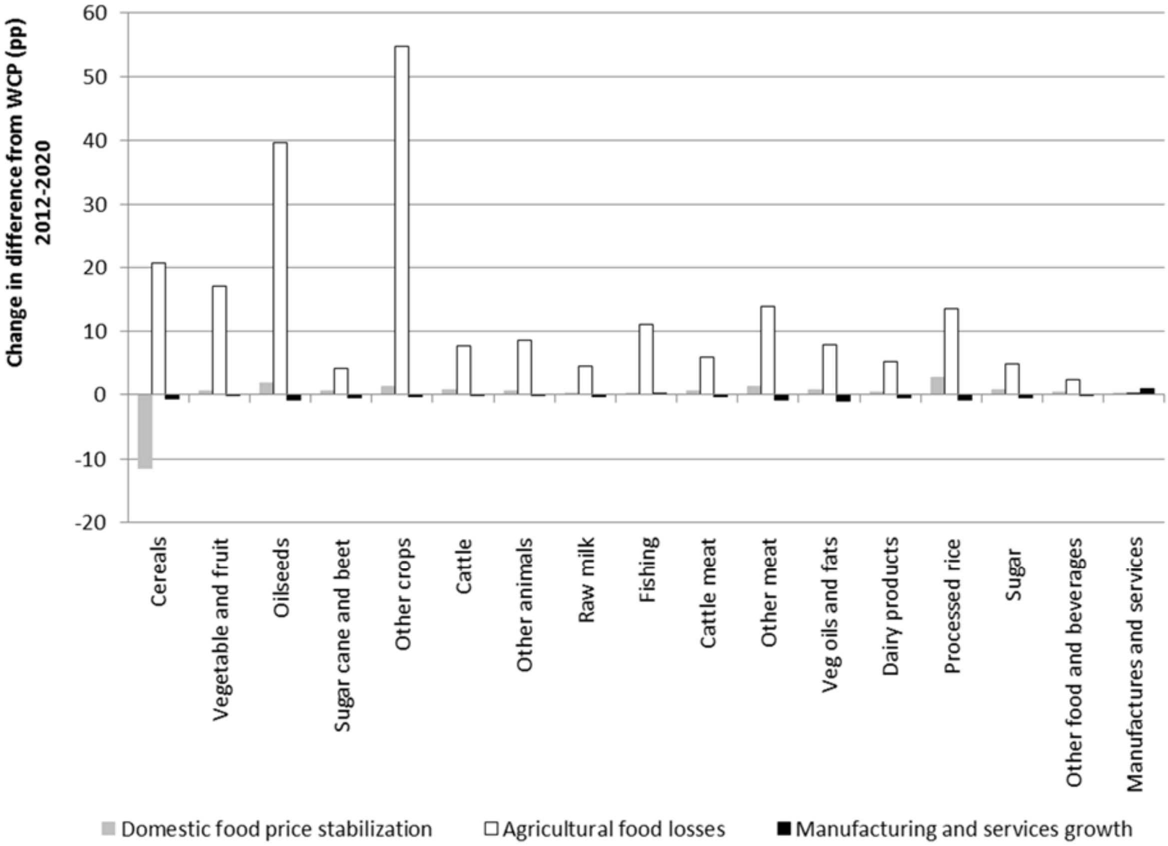

Figure 2: Impacts on production in MENA
Source: MAGNET simulations

In the AFL scenario, agricultural growth targeting food losses in supply results in much lower production costs for the primary agricultural sectors due to improved efficiency in the use of all inputs, including land (land prices are, for example, shown to fall by 12.6 pp). This benefits all primary agricultural sectors, including cereals, which now expand by a lot more than in the first scenario. Production prices for vegetables and fruits, other crops and oil seeds fall the most, by 23.4 pp, 21.2 pp and 17.8 pp respectively. These sectors experience the biggest losses in agricultural supply, and so experience the biggest gains if this were to be reduced (see Table 2). The production of vegetables and fruits, other crops and oil seeds expands by 17 pp, 54.8 pp and 39.7 pp respectively. The relative increase in the production of vegetables and fruit is lower than that 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 from 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 0.9 pp (this is a relatively small absolute number, as this sector comprises over 90% of the value of output generated in MENA).

6.3 Food security and poverty

Income increases in the MENA region in the AFL and MSG scenarios, in line with the development of GDP growth. The DPS scenario hardly affects income, as it generates very limited economic growth in MENA. Figure 3 shows the impacts on per capita household food consumption, in total and from imports and domestic sources, and food prices paid by households.

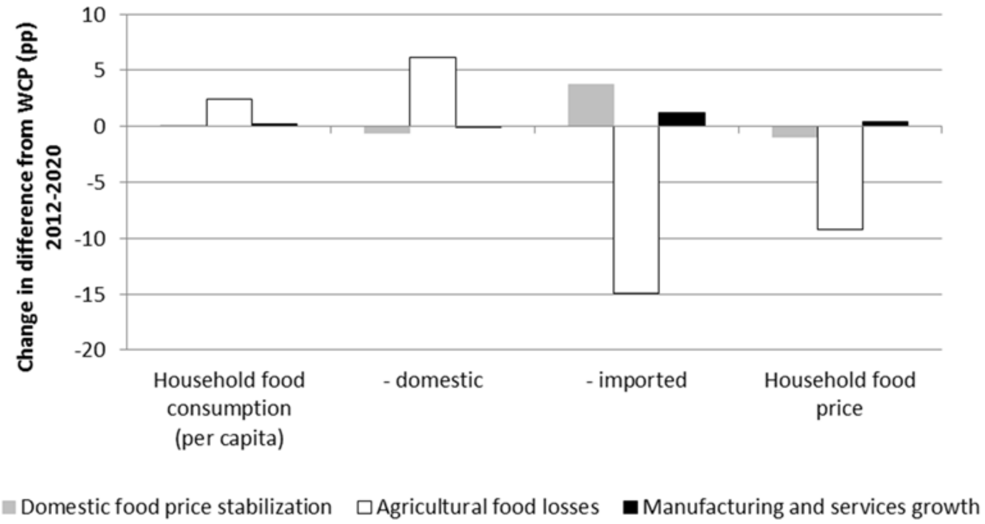

Figure 3: Impacts on food security in MENA
Source: MAGNET simulations.
Note: The food bundle refers to all agri-food commodities consumed by households, and are weighted according to their household budget shares.

The results show that, due to a policy of stabilising domestic food prices via lowering import tariffs on cereals (DPS scenario), household food consumption improves slightly (by 0.1 pp) as a result of the fall in consumer prices (by 0.9 pp). However, household consumption of domestic food decreases (by 0.6 pp) and is replaced by imported food items (increase of consumption by 3.7 pp), in particular of imported cereals, as these become relatively cheap due to the simulated fall in their import tariffs. As a result, the share of imported cereals in total cereal consumption increases by almost 17 pp in 2020.

As shown in Figure 3, household food consumption increases the most in the AFL scenario (by 2.4 pp), and this is mostly because more domestic food is consumed (increase by 6 pp) compared to imported food (decrease by nearly 15 pp). Improving the productivity of the agricultural sector by avoiding agricultural food losses results in lower consumer prices (fall by 9 pp), which 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, therefore, is hardly affected. The increase in household food consumption (by 0.2 pp) stems more from imported food items (increase by 1.2 pp), whereas households overall pay a slightly higher price for food (increase by 0.4 pp).

Changes in food security are a particular concern for rural households, which, with respect to income and with respect to expenditures, depend heavily on food prices. Given that relatively more unskilled labour is employed in rural areas, with lower wages than for skilled labour, and that cereals are the main staple food item in rural areas, the rural unskilled wage-to-cereal price (consumer price faced by households) ratio can be used as an indicator of poverty. A positive (negative) change in this ratio over time implies that more (less) cereals can be bought at a given unskilled wage and thus is a signal of lower (higher) poverty.

The results show that, in all three scenarios, poverty, as measured by the rural unskilled wage-to-cereal price ratio, declines; positive change in the ratio by 2.8 pp, 9 pp and 0.6 pp in the DPS, AFL and MSG scenarios respectively.

Poverty declines the most in the AFL scenario compared to the DPS and MSG scenarios, as cereal prices fall by more, leaving poor households better off when it comes to their purchasing power of food items.

6.4 Welfare

The welfare impacts in each scenario are displayed in Table 4, including welfare changes (measured as equivalent variation) in 2020 in absolute terms (total and per capita), and welfare changes relative to GDP in 2020, so as to provide a sense of magnitude. Since welfare impacts are mostly felt within the MENA region, impacts across other regions of the world are excluded from the table.

Table 4: Welfare impacts in MENA in 2020 (difference from WCP scenario)

Scenario	Million 2007 US$	2007 US$ per capita	Relative to GDP in 2020 (%)
Domestic food price stabilisation	-514	-1	0%
Agricultural food losses	35 496	67	0.8%
Manufacturing and services growth	43 218	81	1.0%

Source: MAGNET simulations

The results reveal that a policy response of lowering import tariffs so as to stabilise domestic cereal prices (DPS scenario) yields small and negative impacts on welfare, primarily due to the negative terms of the trade effect that occurs. The other two responses to rising world food prices lead to welfare gains of around 35 billion 2007 US$ when tackling agricultural food losses (AFL scenario), and 43 billion 2007 US$ when aiming for manufacturing and service-led growth (MSG scenario), or 67 and 81 2007 US$ per capita respectively. These are in the same order of magnitude, but higher for the latter than for the former. Whereas welfare gains from changes in technology are higher in the AFL scenario, there are comparatively lower allocative efficiency gains and, more importantly, negative terms of trade effects due to lower production costs and export prices for agri-food products.

Although costs associated with the policies to reduce food losses and waste have not been taken into account due to a lack of data, the projected welfare gains provide insight into how much measures to tackle agricultural food losses in the region are allowed to cost. Specifically, in this hypothetical scenario, this amounts to an annual 67 US$ per capita in 2007 prices (approximately 35 US$ billion in total), equivalent to 0.8% of GDP in 2020. Using a CPI inflation factor of 1.15 (BLS 2015), the upper boundary on the cost of tackling agricultural food losses amounts to 41 billion current US$, or 77 current US$ per capita. Whilst it could cover the considerable sum of money that may be needed for broad-based measures that are necessary to reduce agricultural food losses and improve productivity, including investments in technical, managerial and human infrastructure, it may be difficult to fund these investments upfront with benefits only coming in later. Note that the costs relating to a manufacturing and service-led growth agenda are also not known and have not been taken into account, and so essentially the same reasoning applies.

7. Conclusions and further research

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

From a diagrammatic analysis of the impacts of reducing food losses in supply, we have learnt that avoiding food losses generally leads to a higher quantity produced and consumed, at a lower cost and price, with welfare gains for producers, consumers, and in total. The results are highly dependent on various factors of influence.

From an applied analysis using the MAGNET model, we find, firstly, that protecting domestic consumers from higher world food prices via lowering import tariffs does not perform well in terms of enhancing economic growth, compared to policies that aim explicitly to generate growth, whether in agriculture or in manufacturing and services. Secondly, trade-offs occur depending on the targeted sectors or actors. Thirdly, in terms of food security, whereas all policies enhance food consumption, protecting domestic consumers from rising world food prices via lowering import tariffs increases their dependence on and hence vulnerability to changes in the world food market (in particular price volatility). Growth that targets food losses in agriculture has the opposite effect, and has a much larger positive impact on food consumption. Manufacturing and service-led growth leads to a limited positive impact on food consumption, and that mainly in terms of imports rather than domestic goods, thereby increasing vulnerability to changes in the world market.

Fourthly, in terms of poverty, the wages of the rural poor relative to the price of staple foods fall in all three scenarios, but most when agricultural food losses are tackled, since food prices fall relatively more. Finally, in terms of welfare, policies promoting agricultural growth by tackling food losses perform slightly worse compared to policies targeting manufacturing and service-led growth, primarily due to deteriorating terms of trade for agri-food products. 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 should act as an upper bound on potential costs. All in all, given their potential to improve food security, policies that aim to tackle agricultural food losses should focus on measures that are cost effective.

Further research should focus on: (1) analysing alternative policy responses to arrive at a more complete view of how best to respond to rising world food prices; (2) disaggregating results across MENA countries and across households to obtain more detailed poverty and food security impacts; and (3) improving the modelling of (tackling) food losses and waste in all stages of the food supply chain across the globe by incorporating food loss and waste percentages and endogenising them, depending on (relative) prices. Aforementioned improvements all rely on the availability of data.

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References

Benson T, Minot N, Pender J, Robles M & Von Braun J, 2013. Information to guide policy responses to higher global food prices: The data and analyses required. Food Policy 38: 47–58.

Breisinger C, Ecker O, Al-Riffai P & Yu B, 2012. Beyond the Arab awakening: Policies and investments for poverty reduction and food security. Food Policy Report, IFPRI, Washington DC.

Bruinsma J, 2003. World agriculture: Towards 2015/30. FAO Perspective. London: Earthscan and Rome: FAO.

BLS, 2015. CPI inflation calculator. Available at http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=1.00&year1=2007&year2=2015

Fan S, Torero M & Heady D, 2011. Urgent action needed to prevent recurrent food crises. IFPRI Policy Brief 16, March, IFPRI, Washington DC.

FAO (Food and Agricultural Organization), 1996. Rome Declaration on World Food Security. World Food Summit, 13–17 November, Rome, Italy.

FAO (Food and Agricultural Organization), 2009. Policy measures taken by governments to reduce the impact of soaring prices (as of 15 December 208). Global Information and Early Warning System on Food and Agriculture (GIEWS). Available at http://www.fao.org/giews/engligh/policy/1.asp

FAO (Food and Agricultural Organization), 2011a. Guide for policy and programmatic actions at country level to address high food prices. Rome: FAO.

FAO (Food and Agricultural Organization), 2011b. Global food losses and food waste: Extent, causes and prevention. Rome: FAO.

FAO (Food and Agricultural Organization), 2014a. State of food and agriculture in the Near East and North Africa region. FAO Regional Conference for the Near East, thirty-second session, 24–28 February, Rome, Italy.

FAO (Food and Agricultural Organization), 2014b. FAO Statistical Yearbook 2014: Near East and North Africa Food and Agriculture. Cairo: FAO Regional Office for the Near East and North Africa.

FAO, WFP & 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 TW, 1997. Global trade analysis: Modelling and applications. Cambridge: Cambridge University Press.

HLPE, 2014. Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. HLPE report 8, HLPE, Rome.

Kader AA, Kitinoja L, Hussein AM, Abdin O, Jabarin A & Sidahmed AE, 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.

Parfitt J, Barthel M & MacNaughton S, 2011. Food waste within food supply chains: Quantification and potential for change to 2050. Philosophical Transactions of the Royal Society B 365(1554): 3065–81.

Rutten M, 2013. What economic theory tells us about the impacts of reducing food losses and/or waste: Implications for research, policy and practice. Agriculture and Food Security 2(13). doi:10.1186/2048-7010-2-13

Rutten M & Verma M, 2014. The impacts of reducing food loss and waste in Ghana: a scenario study using the global economic simulation model MAGNET. LEI Report 2014-035. LEI Wageningen UR, The Hague, Netherlands.

USDA, 2012. International macroeconomic dataset. Economic Research Service, United States Department of Agriculture. Available at http://www.ers.usda.gov/

Von Braun J, 2008. Rising food prices: What should be done? IFPRI Policy Brief April, IFPRI, Washington DC.

Von Braun J, Ahmed A, Asenso-Okyere K, Fan S, Gulati A, Hoddinot J, Pandya-Lorch R, Rosegrant MW, Ruel M, Torero M, Van Rheenen T & Von Grebmer K, 2008. High food prices: The what, who, and how of proposed policy actions. IFPRI Policy Brief May, IFPRI, Washington DC.

Woltjer G & Kuiper M, 2014. The MAGNET model: Module description. LEI Report 14-057, LEI Wageningen UR, Den Haag, Netherlands.

World Bank, 2008. Rising food prices: Policy options and World Bank response. Paper prepared as background to the meetings of the Development Committee, April, World Bank, Washington DC.

World Bank, 2012. Historical data on commodity prices. Available at http://econ.worldbank.org/