ANNEX 1

Simulating the trade-offs and outcomes of food system interventions using the MAGNET model

Food systems provide livelihoods to some 3 billion people who are directly engaged in farming or work in agroprocessing, rural banking or retail, whether self-employed or as temporary or permanent workers. Food systems also provide food and nutrition to people, both in rural and in urban (including peri-urban) areas. This double role of food production – as a source of income and a cost of living – implies that transforming food systems must pay due attention to the different and overlapping roles and interests of farmers, traders and consumers. Optimizing the potential of food systems to support equitable rural livelihoods requires a focus on the upstream, midstream and downstream linkages. But it also requires attending to the potential trade-offs with other food system outcomes.

Policies thus need to address likely trade-offs between outcomes for nutrition, inclusiveness, sustainability and growth. The report's MAGNET[1] analyses of alternative future food system transformation strategies, with a horizon to 2050, provide insights into opportunities and constraints for reaching nutrition, inclusiveness and sustainability goals simultaneously and in an economically efficient and socially just manner. Different extreme scenarios show possible outcomes that take account of interactions – both positive and negative – between changes in production and in consumption through adjustments in trade flows, input and factor use, wages, profits and prices.

1 MAGNET stands for Modular Applied GeNeral Equilibrium Tool.

Assessing the potential impact of policy changes using stylized food system modelling

The MAGNET modelling framework generates simulations of the impact of major policy shifts on four key food system dimensions: nutrition, inclusiveness, efficiency and sustainability, defined by 28 indicators that broadly measure progress in SDG performance (**TABLE A1.1**). Changes in these 28 indicators due to targeted policy incentives are reported consistently – to enable comparisons across simulated interventions, and to keep overall food system impacts in view when diving more deeply into parts of the food system.

TABLE A1.1 MAGNET FOOD SYSTEM INDICATORS

NUTRITION	**INCLUSIVENESS**
Share of calories from non-cereals (N1)	Lowest skilled agricultural wage/cereal price (I1)
Fruit and vegetable consumption (N2)	Lowest skilled agricultural wage/healthy diet cost (I2)
Shannon diversity index of diet (N3)	Lowest skilled wage/other wages (economy-wide) (I3)
Poultry-fish/red meat consumption (N4)	Lowest skilled agricultural wage/lowest skilled non-agricultural wage (I4)
Vitamin A (N5)	Lowest skilled non-agricultural share in employment (I5)
Zinc (N6)	Labour share in GDP (I6)
Perishables with food safety risks (fruits, vegetables and animal products) (N7)	One minus labour-based GINI (I7)
SUSTAINABILITY	**ECONOMY**
Agricultural land area (S1)	Structural transformation: shares of non-agricultural value added (E1)
Pasture land area (S2)	Rural transformation: agricultural-value-added per worker (E2)
Shannon diversity index of crop land use (S3)	Agricultural employment (E3)
Total abstracted irrigated water (S4)	Food supply chain employment (E4)
Wild fish/aquaculture production (S5)	Food self-sufficiency rate (E5)
GHG emissions by agricultural sectors (S6)	Food price (index) (E6)
Total GHG emissions (production sectors + final demand) (S7)	Non-food share in household expenditures (E7)

The simulations generate average impacts based on data for 71 low- and middle-income countries. Additional details are available in Kuiper and Verma (2021), where these 71 countries are grouped using a similar approach, based on the degree of structural transformation (ST) and rural transformation (RT) but using MAGNET-specific data and thresholds. In addition, differences between economies are based on projected rates of economic growth from 2019 to 2050 to highlight changes in the poorest but fastest-growing subgroups within the ST-RT grouping when these differ substantially from the average impacts in low- and middle-income countries.

The business-as-usual (BaU) scenario is the reference for the foresight results throughout the report, serving as background to judge different types of food system interventions. It captures the projected food system changes from 2019 to 2050 resulting from key macro drivers, such as population growth, technology changes, total factor productivity, and labour force composition. Details on the technical set-up of all scenarios are available in Kuiper and Verma (2021).

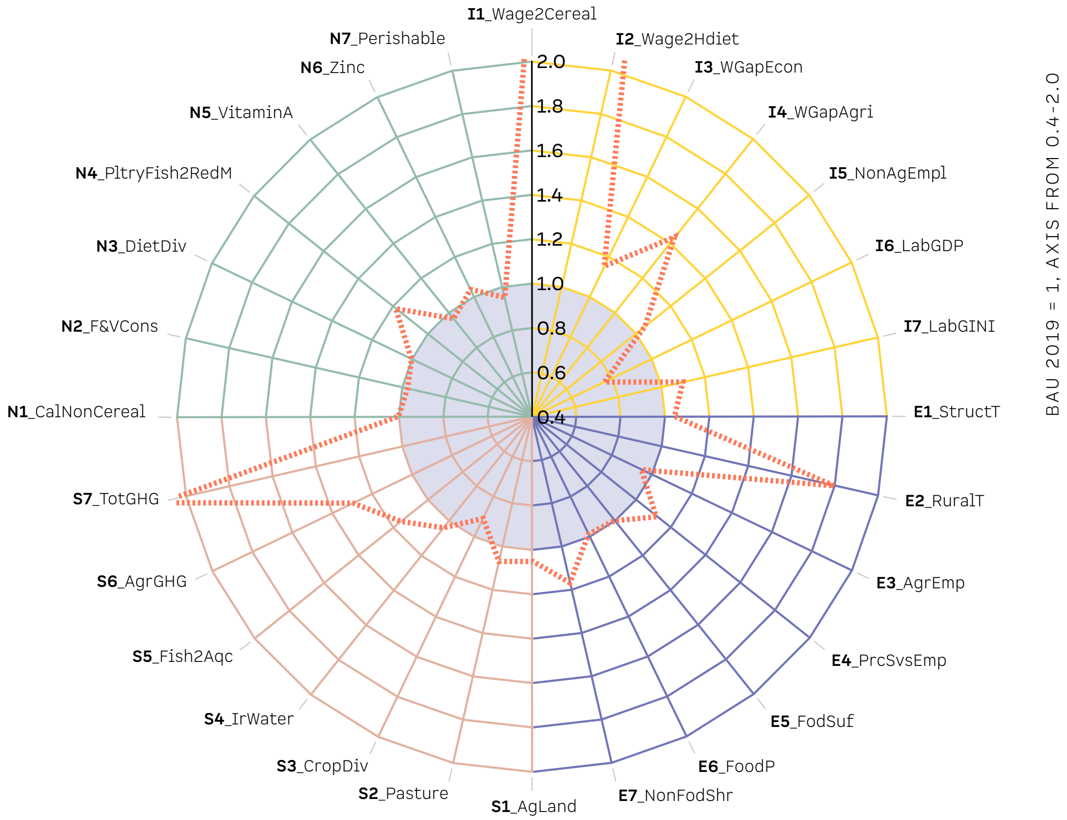
To identify food system transformation challenges beyond the current Sustainable Development Goal (SDG) framework – and to show the costs of inaction – the foresight analysis takes a time horizon to 2050. Simulation outcomes suggest the need for accelerating efforts to approach the SDG targets. Note that it is not yet possible to account for the effects of COVID-19, since its long-run impacts are not yet clear enough to be reflected in the growth paths, which could be substantially lower than those in the current middle-of-the-road simulation.

The business-as-usual baseline

FIGURE A1.1 THE BASELINE – CONTINUING WITH BUSINESS AS USUAL, 2019 TO 2050

Nutrition (+)
Large nutrition improvements in the poorest economies driven by fast economic growth outpacing population growth

Inclusiveness (+)
Improvements in affordability and income distribution among types of labour but not with capital, while workers in largely stationary economies are left behind



Pressure on sustainability (-)
Population and fossil-based economic growth put a huge strain on natural resources, especially through GHG emissions

Economy (+)
Rural transformation outpaces structural transformation while agriculture remains an important source of employment

2019 BaU (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

In all figures, the grey circle represents the 2019 reference point – for the 2050 BaU scores for all counterfactual scenarios in the simulations – with the value of each of the 28 indicators normalized at 1. The dashed line then presents the change for each indicator relative to this uniform reference point. Movements outward are judged as positive in the nutrition, inclusiveness and economy quadrants. The labour-based GINI indicator, for example, is defined so that an increase signals greater equality of wage incomes. Only in the sustainability quadrant is an outward movement judged as negative, signalling increased pressure on natural resources. An increase in total GHG emissions, for example, increases the rate of climate change.

The BaU scenario indicates that economic development is likely to be accompanied by some progress in nutrition (particularly in the more diversified economies), but with strong negative implications for the natural resource base. Land use will be reaching its limits and more intensive agricultural production leads to higher emissions. Economic growth translates into higher per capita income, and labour transfers out of agriculture to higher paying non-agricultural jobs contribute to declining wage inequalities.

Simulation 1 Imposing a flexitarian diet

A healthy and sustainable diet supports the poorest agricultural workers while keeping more people in agriculture and increasing food prices

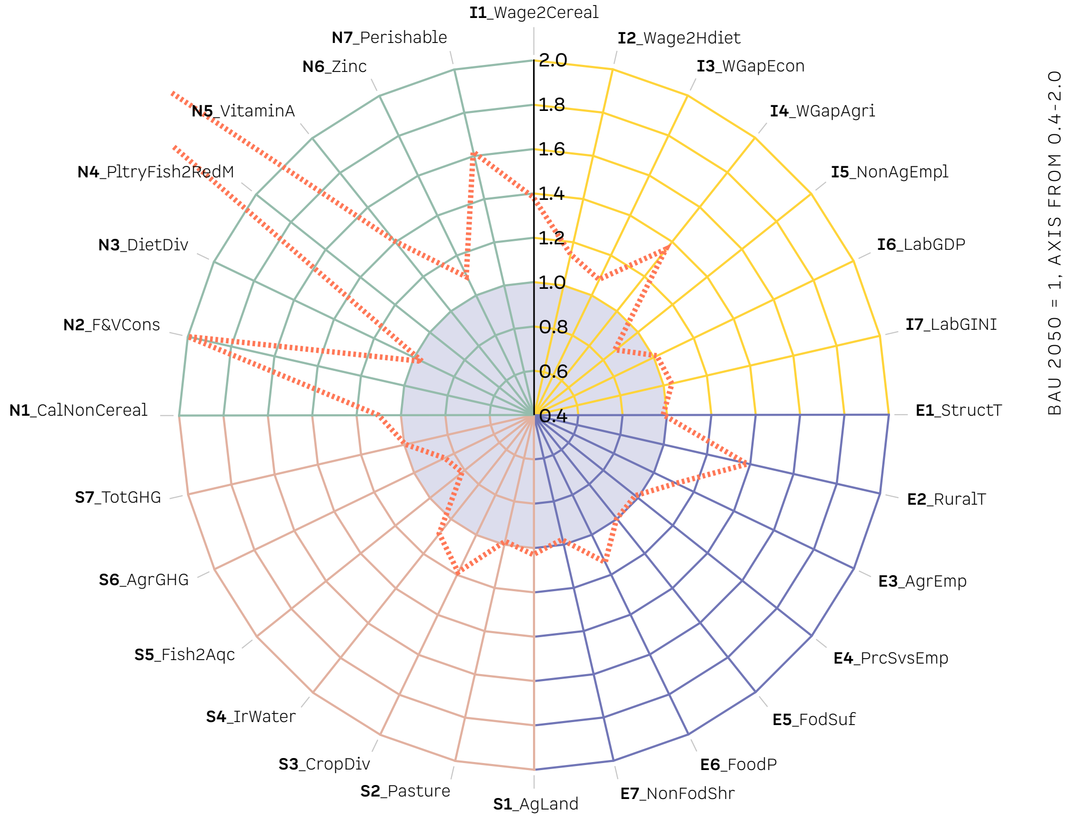
One option for fundamental food system changes is a global shift to a healthy and sustainable diet. The diet scenario uses a flexitarian healthy diet derived from Springmann et al. (2018) and designed to simultaneously reduce GHG emissions and diet-related non-communicable diseases. The diet is imposed in MAGNET through a preference shift, altering the demand system such that households consume the flexitarian diet irrespective of prices or income.

By design, the nutrition indicators improve strongly, while agricultural GHG emissions (S6) contract as meat consumption is restricted. The reduction in total GHG emissions (S7) including non-agricultural sectors is much more moderate, signalling considerable leakage of GHG reductions as households change their expenditure patterns. Following the reorientation towards more plant-based diets, pastures contract (S2) but total agricultural land (S1) and use of irrigation water expand (S4).

FIGURE A1.2 IMPOSING A FLEXITARIAN DIET

Nutrition (+)
The imposed diet and thus nutrition changes vary depending on the BAU diets

Inclusiveness (+)
Diet transformation supports the poorest agricultural workers while keeping more people employed in agriculture



Pressure on sustainability (-)
Strong decrease in agricultural GHG emissions with more limited total GHG reduction and increasing pressure on water resources

Economy (+)
Healthy diets are less affordable for non-agricultural workers; rural transformation boosted while structural transformation slows

2050 BaU results (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

While inclusiveness is not part of the diet rationale, its stimulus to primary production increases demand for low-skilled agricultural labour (a core input in agricultural production in low- and middle-countries) raising its wage. As a result, the wage gap between low-skilled workers and all other workers (I3) and low-skilled non-agricultural workers (I4) closes, pulling more workers into agriculture (I5). Affordability of both cereals (I1) and a healthy diet (I2) improves as the agricultural wage increases of low-skilled workers outpace food price increases (E6). Despite wage increases for low-skilled agricultural workers, overall income inequality appears stable according to the labour share in GDP (I6), so owners of land and capital also benefit from the diet shift. The labour-based GINI (I7), however, shows an improvement, reflecting the fact that while more people remain in agriculture, their wages are increasing relative to the wages of other workers.

The small average decrease in non-food share of household expenditures (E7) hides a much stronger decline in the poorest group of agriculture-focused economies, signalling concerns for the affordability of a healthy diet for lower-paid workers in industry and services.

Simulation 2 Doubling livestock and aquaculture feed productivity

Doubling the productivity of feed for livestock and aquaculture increases the affordability of food but increases wages gaps for the lowest skilled

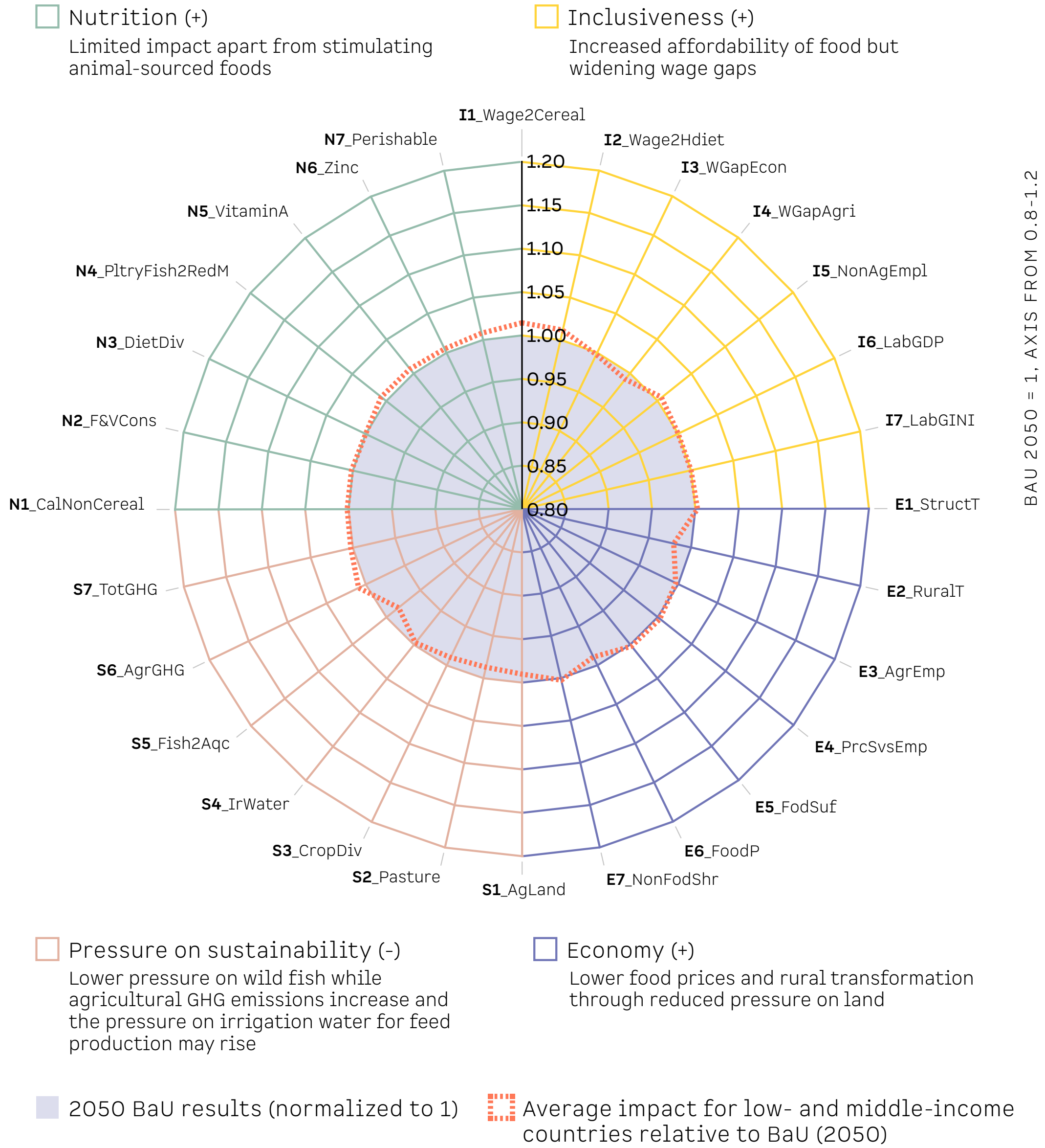
The simulation builds on the mechanisms where rising incomes increase demand for meat and fish, meanwhile increasing pressure on natural resources in the BaU. Most notable is the BaU increase in pasture area, already the largest agricultural land use category. Intensification of production may reduce pressure on land and on wild fish stocks by stimulating aquaculture. This is simulated by doubling the BaU increases in feed productivity.

Increased feed productivity stimulates livestock and aquaculture production, while reducing pressure on pastures (S2) and wild fish stocks (S5). Hidden in the average response is a much stronger contraction of pastureland in land-scarce economies already oriented towards feed use and thus well placed to benefit from the productivity increase. Increased feed productivity in livestock spills over into crop sectors through increased demand for feed crops and lower land prices, which stimulate demand for land, resulting in a modest overall decline in agricultural land use (S1). Stimulating livestock production results in a small increase in total agricultural GHG emissions (S6).

Less demand for labour in livestock is not fully compensated by increased demand in crop production, resulting in a small decrease in agricultural wages. This wage decrease is outpaced by decreasing food prices (E6), so the affordability of cereals (I1) and healthy diets (I2) improves. Lower food prices create room for non-food expenditures, pushing up non-agricultural wages in addition to the small decrease in agricultural wages.

The stimulus of livestock and aquaculture production increases the consumption of animal-sourced foods in all economies by lowering their price, reflected by the small increase in perishable products (N7), while fruit and vegetable consumption remains stable (N2). Increased consumption of fish from aquaculture raises poultry and fish consumption relative to red meat (N4). While the affordability of cereals (I1) and a healthy diet (I2) improves for the lowest-paid workers, the stimulus of livestock and aquaculture through feed productivity has a limited impact on average nutrition patterns.

FIGURE A1.3 DOUBLING THE PRODUCTIVITY OF FEED FOR LIVESTOCK AND AQUACULTURE



Source: Kuiper and Verma, 2021.

The total changes in the economy are also limited, apart from lower food prices (E6) and a slowing of rural transformation (E2). Reduced pressure on land reduces agricultural value added with less land use (S1) at lower prices, while agricultural employment contracts only very slightly (E3), thus lowering the value added per worker used to define rural transformation.

Simulation 3 Halving yield gaps in cereals and fruits and vegetables

Positive for inclusiveness and nutrition, but agricultural emissions increase

The effects of closing yield gaps were explored in a MAGNET scenario simulating the effects of halving the yield gaps for cereals and fruits and vegetables – essentially, doubling the current productivity of land with no increase in inputs (or other costs). The results show how closing yield gaps changes the trajectory of food system transformations in 2050, compared with the baseline BaU scenario for all low- and middle-income economies (**FIGURE A1.4**).

Overall, the simulation shows that the effects of the induced shock on inclusiveness are positive, as are nutritional impacts. The productivity increase lowers food prices (E6) compared with the simulated prices of 2050 under a BaU scenario (represented by the grey circle). Lower food prices and higher low-skilled agricultural wages boost the affordability of both cereals (I1) and a healthy diet (I2). These higher wages also pull low-skilled workers out of non-agricultural employment (I5).

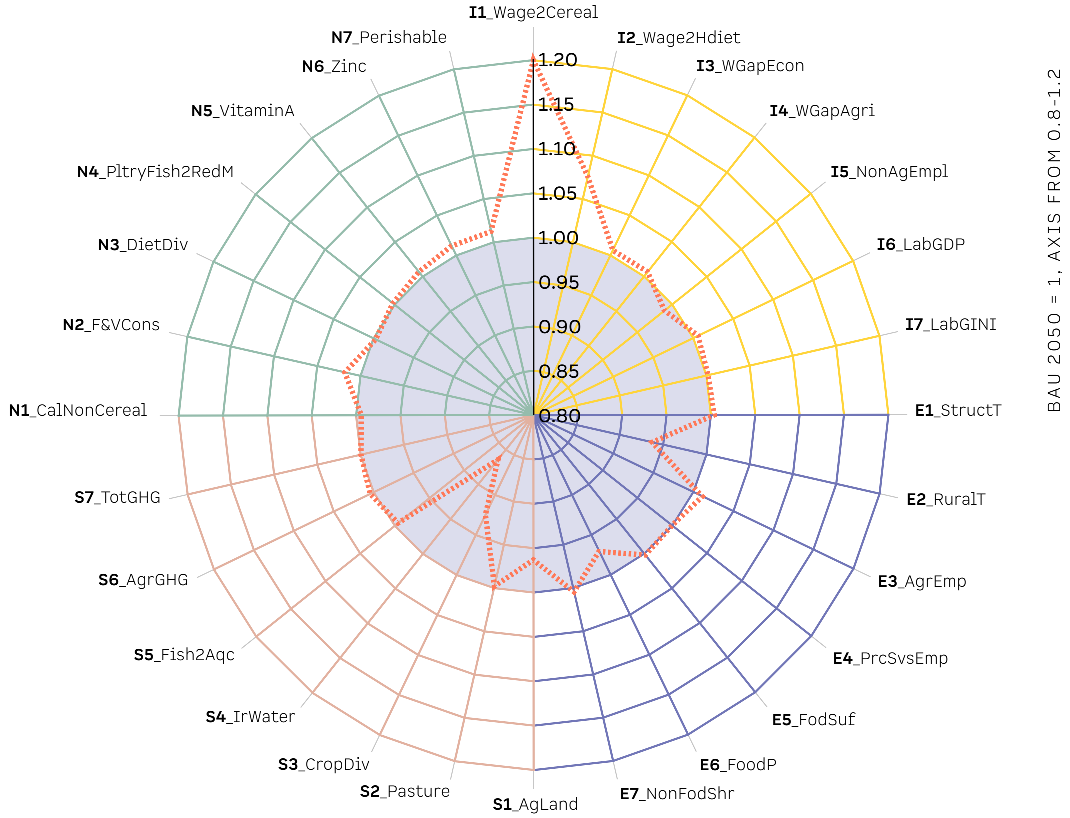
Lower food prices create more room for non-food expenditure shares (E7), benefiting consumers. Lower food prices reduce the income of agricultural producers through lower land payments and contractions in land areas (S1). Combined with more agricultural workers (I5), this slows the rural transformation (E2), defined as agricultural factor payments over number of workers. For the lower-income economies, increased agricultural productivity further stimulates structural transformation (E1), with the value-added shares of industries and services in GDP increasing. While primary inputs for processing and services sectors become cheaper, this does not translate to an increase in employment (E4).

Increased productivity of cereals and horticulture lowers demand for irrigation water (S4). It also reduces the amount of agricultural land (S1), since the same production levels can be attained with less land, freeing non-land inputs for use elsewhere. Increased cereal productivity also allows a strong move away from costly land, resulting in the largest agricultural land contraction and a small increase in total pasture area (S2). Limited space for pastures drives an increase in the share of land used for oil seeds, which can be used for feed (directly or through the oilcake by-product from vegetable oil production). The increased productivity of cereals and fruits and vegetables is thus used in part to increase livestock production, increasing agricultural GHG emissions (S6).

FIGURE A1.4 HALVING YIELD GAPS IN CEREALS AND FRUITS AND VEGETABLES

Nutrition (+)
Indirect stimulus of meat consumption through reduced feed costs

Inclusiveness (+)
Rising agricultural wages, declining income for landowners



Pressure on sustainability (-)
Less water and land but more GHG emissions from livestock stimulated by lower feed costs

Economy (+)
Slower rural transformation, no stimulus of food system employment beyond the primary stage

2050 BaU results (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

Simulation 4 Halving farm gate food losses

Reducing farm gate losses has mixed prospects for inclusiveness, improves nutrition and has modest effects on sustainability

This simulation halves global food loss rates for cereals and fruits and vegetables and is derived from Stathers et al. (2020). Because reduced losses imply that more usable output is obtained from the same inputs, MAGNET simulates a farm gate output productivity increase at 50 per cent of the loss percentage. The same sectors are targeted as in the yield gap scenario, but productivity is not tied to the use of land. This strongly affects the food system impacts, showing the importance of intervention design.

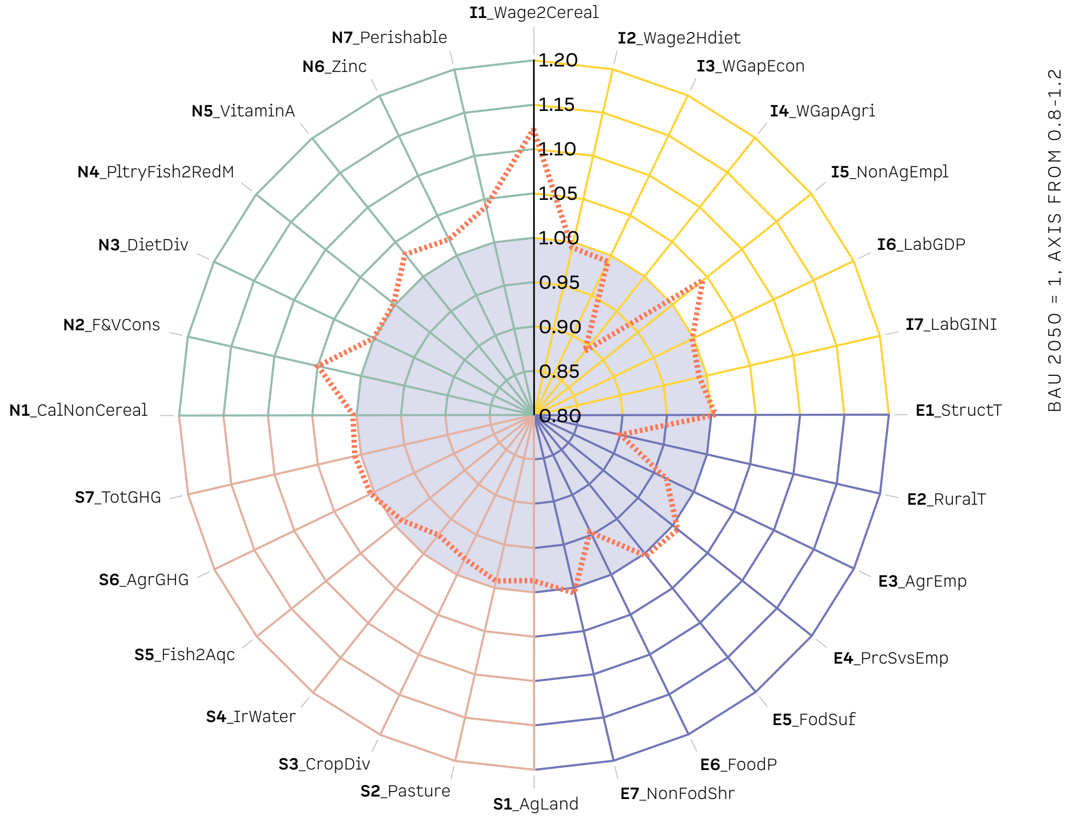
With closing yield gaps (CHAPTER 3), the productivity increases were tied to land. This limited the benefits for economies with little land, reducing the average impact on nutrition. With less food lost, the availability of output increases irrespective of inputs used, reflected by a positive change in nutrition indicators over all economies. Despite a lower increase in productivity for fruits and vegetables (17 per cent) than in the simulation closing yield gaps (16-112 per cent) in chapter 3, there is a stronger increase in household fruit and vegetable consumption (N2). This indicates that diets benefit more directly from food loss reductions raising the productivity of all inputs, than from closing yield gaps and tying the productivity increase to the use of land.

As with closing yield gaps, food prices (E6) go down as cereal and fruit and vegetable productivity increases, but the impacts on affordability are now tempered by lower wages for low-skilled agricultural workers. Lower food prices create more space for non-food expenditures at the national level, as lower food prices stimulate food demand only for the poorest households unable to afford the desired amount of food. The increased demand for non-food production pulls low-skilled workers into non-agricultural employment (I5) through higher non-agricultural wages. At the same time, the output productivity pushes labour (most of low-skilled) out of agriculture (E3) as fewer inputs (including labour) are needed to produce the same amount of output. This lowers the agricultural wages of the low-skilled, further widening the wage gap between them and those employed in non-agriculture (I4), and also widening the wage gap between them and other workers (I3). The net result is an improvement in the affordability of cereals (I1) and a small decrease in the affordability of a healthy diet (I2). While the drop in low-skilled agricultural wages on average outpaces the drop in cost of a healthy diet, this hides variation across economies. In the poorer fast-growing economies, the affordability of a healthy diet improves against BaU, thus improving the opportunities for making healthier diet choices.

FIGURE A1.5 HALVING FARM GATE FOOD LOSSES FOR CEREALS AND FRUITS AND VEGETABLES

Nutrition (+)
Uniform improvements in diets as regional characteristics are less important with a uniform increase in input productivity

Inclusiveness (+)
Increased overall affordability of cereals but not of healthy diets, with wages of agricultural low-skilled workers falling behind



Pressure on sustainability (-)
A little less pressure on water and land but an increase in agricultural GHG emissions as impacts spread over all inputs instead of focusing on land

Economy (+)
Lower food prices spread across labour and land slows the rural transformation and reduces employment in primary production

2050 BaU results (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

The reduced demand for inputs to achieve the same amount of output is reflected in less pressure on natural resources. Overall changes are similar to closing yield gaps in reducing pressure on water (S4) and land (S1, S2). But a minimal increase in agricultural GHG emissions (S6) linked to spillovers into cheaper feed production stimulates livestock production, while a stimulus of non-food production raises total GHG emissions (S7).

Simulation 5 Increasing import tariffs to promote food self-sufficiency

Import tariffs reduce nutrition security among the poorest people in low- and middle-income countries, at the expense of sustainability

COVID-19 rekindled interest in reducing reliance on global trade networks by reducing food imports. This simulation promotes food self-sufficiency in low- and middle-income countries by a generic doubling of imported food prices, either for direct consumption or as intermediate inputs for further processing by domestic industries. There are no additional tariffs on agricultural inputs (seed, fertilizers and feed).

Despite the intended profound implications for food trade – imports of food items and raw materials for the agro-industry are roughly halved – there are substantial trade-offs in other areas. Not taxing agricultural inputs creates opportunities for agricultural intensification. These opportunities, alongside increased pressure on domestic production in food-importing economies, support rural transformation (E2), at the cost of delaying structural transformation (E1), by pulling resources back into primary production.

Trade protection increases pressure on domestic production in food-importing economies, where food prices rise, while in prices in food-exporting economies may drop. Averaging over all low- and middle-income countries, food prices increase (E6), making cereal-based diets less affordable for the lowest-paid (I1). In countries with limited land resources, land rental prices increase most, and landowners benefit from increased demand for agricultural land. In countries better endowed with land and labour, the loss of export markets leads to a reduction in rural employment and a decline in agricultural wages. On average over all low- and middle-income countries, however, agricultural low-skilled wages increase, reducing the gaps between them and both non-agricultural low-skilled wages (I4) and more skilled workers (I3). Apart from the pull of higher agricultural wages, low-skilled workers are also pushed out of non-agricultural employment (I5) because less income is available for non-food purchases (E7).

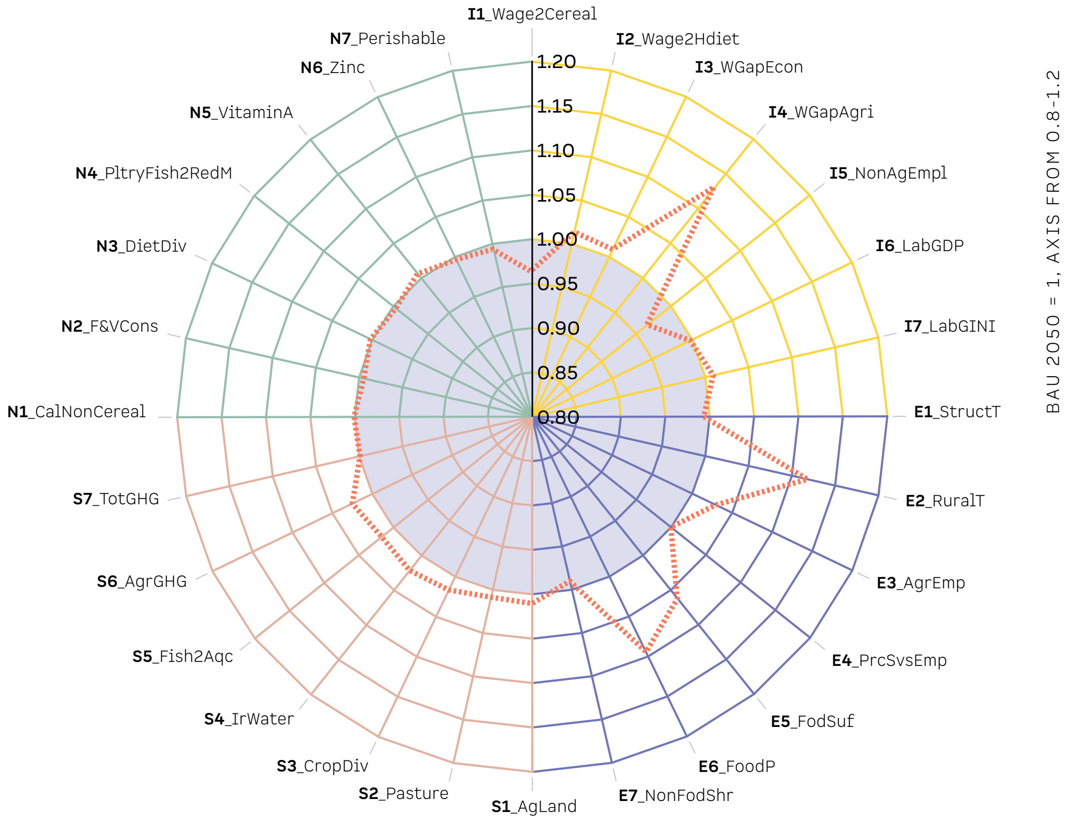
With average private household income roughly stable, economy-specific changes in food prices generate a varying pattern in nutrition indicators not visible on average for the low- and middle-income countries, apart from the drop in affordability of cereals for the poorest (I1), signalling a substantial decline in nutritional status of the poorest.

In addition, pressure on domestic natural resources increases (on land, water, wild fish), even while feed and fertilizer imports are allowed, and somewhat relieve land constraints. The contraction of international trade reduces fossil fuel emissions associated with transport, while the declining demand for non-food expenditure also reduces fossil fuel emissions. But increased land use and intensified production of crops (fertilizer) and livestock (feed) increase agricultural GHG emissions (S6) so that in all economies total emissions increase slightly (S7).

FIGURE A1.6 INCREASING IMPORT TARIFFS TO PROMOTE FOOD SELF-SUFFICIENCY

Nutrition (+)
The limited average change hides nutritional decline in poorest economies where food price increases outstrip agricultural income gains

Inclusiveness (+)
Crashing affordability of cereals and healthy diets despite closing wage gaps; landowners benefit from increased demand for agricultural land



Pressure on sustainability (-)
Pressure on land, water, wild fish and increasing agricultural GHG emissions

Economy (+)
Increased rural transformation at cost of structural transformation; employment in food processing and services increases

2050 BaU results (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

Simulation 6 Increasing midstream employment by subsidizing low-skilled labour

Increasing low-skilled labour in midstream activities improves inclusiveness but has mixed impacts on nutrition and sustainability

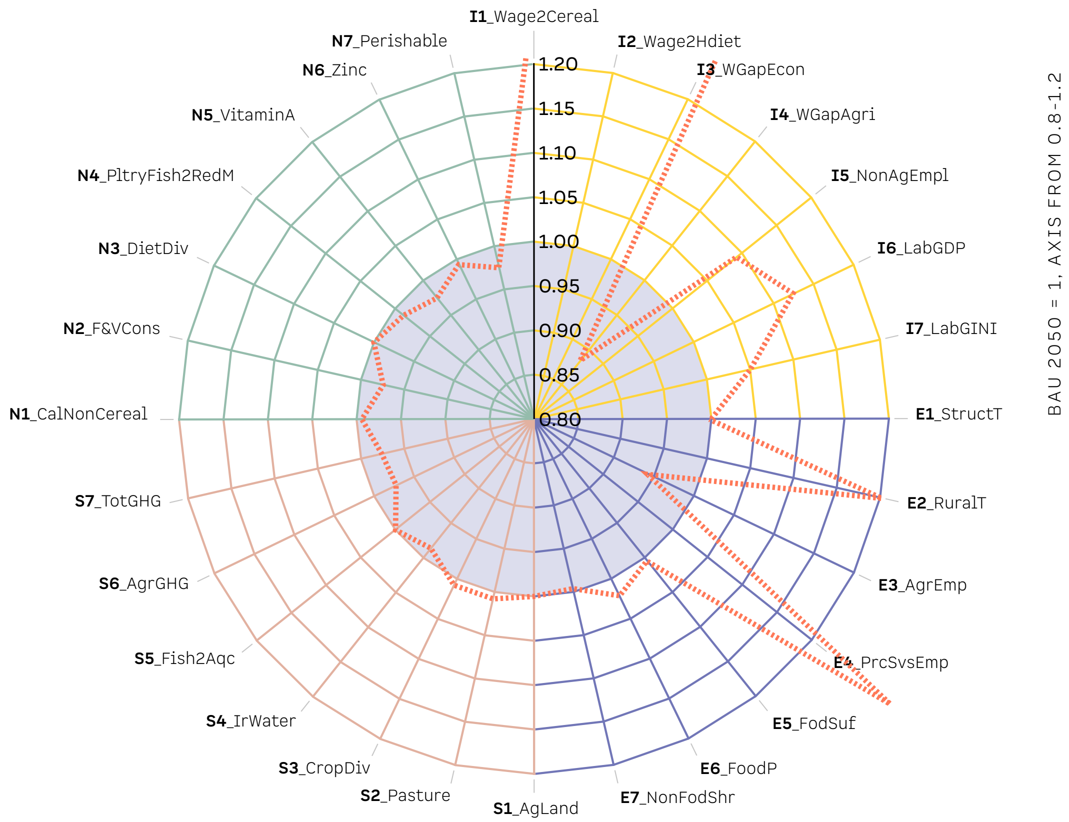
A major increase in midstream employment might interact with other food system features and create unforeseen trade-offs with inclusivity, nutrition, economic or environmental outcomes. The midstream employment scenario subsidizes the low-skilled labour in food processing, wholesale and transport at a rate equal to half the projected low-skilled wage increase under the (BaU) scenario. The strong pull of labour into processing (E4) makes low-skilled labour more scarce. This promotes rural transformation (E2) by boosting wages and reducing the number of agricultural workers (E3). It also raises food prices (E6), reducing the expenditures on non-food products (E7).

The simulation indicates a generally positive correlation with indicators of inclusivity. The increased demand for low-skilled labour increases their wage, reducing the wage gap between these workers and other types of workers (I3). The combination of higher wages for the poorest and high numbers of employment in better paying non-primary sectors translates into substantial improvements in the labour-based GINI (I7) and an increasing labour share in GDP (I6). The boost to agricultural wages by far outpaces food price increases, improving the affordability of cereals (I1) and healthy diets (I2) despite the higher food prices (E6). Stimulating non-agricultural low-skilled jobs, however, also substantially widens the gap between agricultural and non-agricultural low-skilled workers (I4). Although all low-skilled workers benefit from the increased demand for them, those able to secure a job in the midstream sectors will benefit more than those remaining in agriculture.

FIGURE A1.7 INCREASING MIDSTREAM EMPLOYMENT BY SUBSIDIZING LOW-SKILLED LABOUR

Nutrition (+)
Worsening of nutrition indicators as wages of non-targeted workers decrease with rising food prices

Inclusiveness (+)
Inclusiveness improves despite fast-widening gap between agricultural and non-agricultural wages of low-skilled workers



Pressure on sustainability (-)
Shifting away from primary production reduces pressure on natural resources but regional water use may increase

Economy (+)
Accelerating rural transformation and shifting imports from processed to primary food products

2050 BaU results (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

The simulation points to a possible trade-off with nutrition. Higher wages in agricultural production – as workers leave the sector for midstream employment, pushing agricultural wages up – lead to higher food prices, particularly for labour-intensive crops such as fruits and vegetables. Wages of higher-skilled workers (not targeted by the subsidy) fall as they are pushed out of midstream sectors. On average, this reduces income and negatively affects nutrition, though the impacts vary strongly across economies depending on the composition of the labour force.

On potential trade-offs with environmental factors, the overall effect of a shift out of primary production to midstream activities reduces pressure on natural resources in low- and middle-income countries, notably total GHG emissions (linked to less demand for non-food products) and agricultural GHG emissions from less domestic primary production. This is in part a shift of natural resource use to high-income economies not subject to the low- or middle-income country midstream employment stimulus, from which primary imports are sourced as domestic production becomes increasingly expensive.

Simulation 7 Halving the growth of processed food consumption

Coarse targeting of processed food consumption reduces food demand and worsens inclusiveness by contracting primary production

Increasing consumption of ultra-processed food is a concern, but beyond the reach of the MAGNET product detail. As part of a broader shift towards processed foods with rising incomes, the processed food scenario halves BaU growth rates of processed food consumption (a large but not further differentiated product in MAGNET). The simulation targets both direct purchases of processed food and food services (a main channel for processed food consumption) through a tax on household consumption.

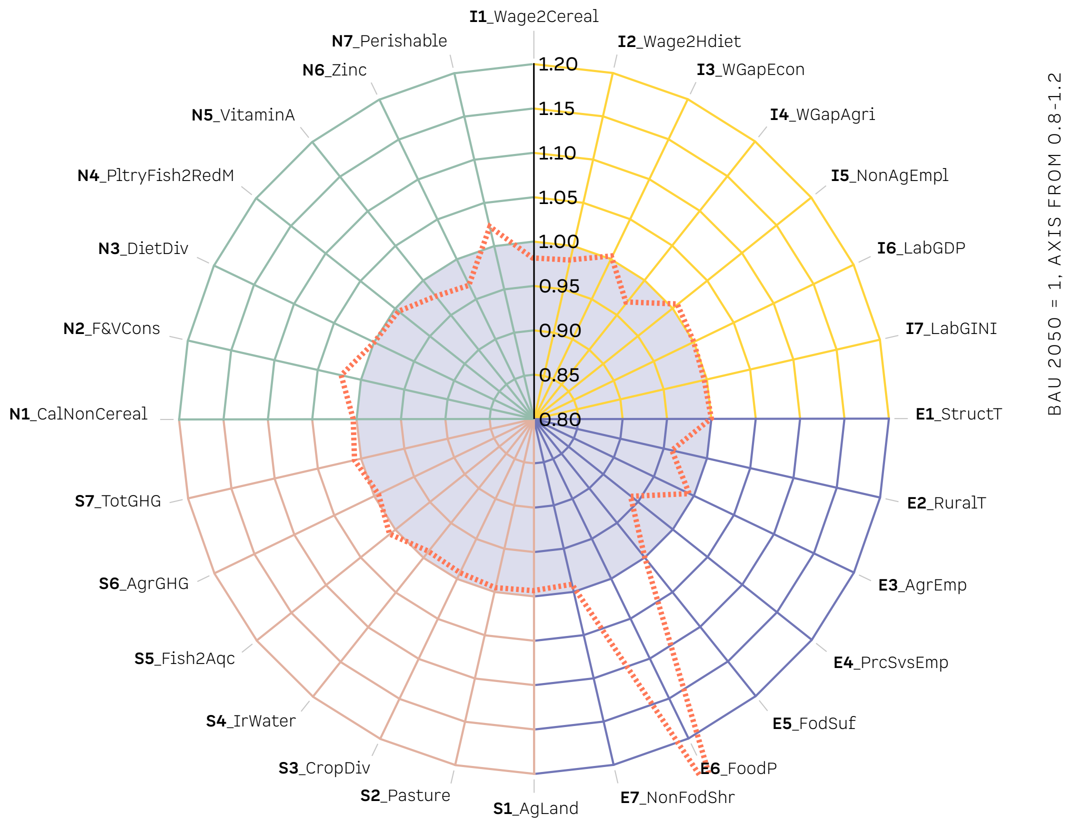
The worsening of several nutrition indicators – ratio of poultry and fish to red meat (N4, vitamin A (N5), zinc (N6) – shows the importance of well-targeted interventions in processed food consumption because many processed foods make a positive contribution to diets. Taxing processed food consumption shifts consumption to meat and fish, sugar, and fruits and vegetables. These shifts are not enough to compensate for lost micronutrient deliveries through the blunt targeting of processed food, and they signal that the consumption taxes reduce overall food consumption by strongly increasing food prices for households (E6).

In low- and middle-income countries, the average changes in non-food shares of household expenditures (E7) are very moderate. They hide strong reductions in poorer economies, where food forms a large share of household expenditures and has much stronger BaU growth requiring higher taxes. Employment in processing and food services (E4) is reduced by the halving of demand for processed food and food services.

FIGURE A1.8 HALVING THE GROWTH OF PROCESSED FOOD AND FOOD SERVICE CONSUMPTION

Nutrition (+)
Increase in fruits and vegetables and animal-sourced foods, but not enough to maintain micronutrient flows from the aggregate processed food commodity

Inclusiveness (+)
Coarse targeting of processed food reduces food demand, worsening inclusiveness by contracting primary production, except for economies increasing exports



Pressure on sustainability (-)
Less food production lowers pressure on natural resources, except in regions increasingly turning towards exports

Economy (+)
More expensive food takes a larger share of household expenditures, with fewer jobs up the food supply chain and a slowing of rural transformation in most economies

2050 BaU results (normalized to 1)

Average impact for low- and middle-income countries relative to BaU (2050)

Source: Kuiper and Verma, 2021.

While the taxes increase the household cost of processed food and food services, they lower the market price as demand and thus production of these commodities contracts. The consumption of non-taxed food increases only moderately through an interplay of three factors: remaining processed food and food service consumption is much more costly, leaving less budget for other food. An overall reduction in demand for primary production lowers both agricultural wages and returns to land, affecting incomes of the poorest households. Increased demand for primary and non-taxed processed foods increases their market price.

Less affordability of cereals (I1) and a healthy diet (I2) result from higher consumer food prices and lower agricultural wages. Low-skilled agricultural workers are affected more than others – as signalled by the widening wage gap between them and other workers (I3) and low-skilled workers in non-agriculture (I4), pushing them out of agriculture (I5). The only economies escaping this worsening inclusiveness are those building on agricultural endowments to increase exports. This allows an increase in agricultural wages, which maintains the affordability of cereals and healthy diets despite closing wage gaps.

Summarizing MAGNET simulation results across food system components

Although the simulations have not been designed to highlight how intervention design affects outcomes, we can compare results by simulation to the overall assessment of synergies and trade-offs to gain some insight into the importance of intervention design. To this end, we group the simulations by primary producer, supply chain and consumer. We then select a reference indicator best matching shared objectives for each group of simulations to establish common ground for a comparison across simulations. Converting simulation indicator scores for all low- and middle-income economies to correlations to the reference indicator can highlight how choices in intervention design result in different synergies and trade-offs (**TABLE A1.1**).

FIGURE A1.9 SYNERGIES AND TRADE-OFFS: EFFECTS OF DIFFERENT TYPES OF POLICIES ON FOOD SYSTEM OUTCOMES

Note: Three key indicators were selected in each food system domain (outlined in CHAPTER 1) closely linked to objectives of food system policies (N1, N,2, N4 for nutrition; I2, I4, I7 for inclusiveness, E1, E2, E5 for economy, S1, S4, S6 for sustainability).
Source: MAGNET simulations.

Reducing land area by increasing productivity of primary producers. Three simulations implement different types of productivity increases at the primary production stage: reduction of yield gaps and food loss and improvement in feed productivity. They share a common impact of reducing the agricultural land area. This creates synergies with most sustainability objectives but trade-offs with inclusiveness and economic growth objectives. The productivity increases result in overall synergies with nutrition. Reducing the yield gap stimulates the use of (hired) labour and lowers food prices, but also delays outflows from agriculture and stimulates the demand for non-food commodities, while improving the comparative trade advantage relative to high-income countries.

Income distribution and import dependency with supply chain interventions. Two distinct interventions in the supply chain are simulated: promoting midstream employment and reducing food import dependency. Pulling substantial numbers of workers out of primary production into midstream employment increases the primary production costs. Higher wages for agricultural labourers allow an improvement in healthy diet affordability alongside an improved GINI, but increase the wage gap. As food prices increase and only part of the workers experience increased wages a trade-off with nutrition objectives appears. Moreover, the contraction in primary production generates synergies with sustainability objectives. But increasing food self-sufficiency by raising import tariffs mainly leads to trade-offs with nutrition due to less affordability of healthy diets. The import barriers for primary and processed foods stimulate domestic food production but generate trade-offs with sustainability as more land is needed to replace the imports from more efficient economies.

Fruit and vegetable consumption in consumer-focused simulations. Two simulations alter the food system by changing household consumption decisions: imposing a flexitarian diet and halving the consumption of processed food. Overall increased fruit and vegetable consumption is associated with synergies in nutrition and inclusiveness, but trade-offs on economy and sustainability. The diet simulation improves agricultural wages and the affordability of healthy diets, while reducing GHG emissions. Although very appealing, simulation may overestimate gains as it relies on a preference shift that is costless. In contrast, the processed food simulation relies on taxes, using the observed responsiveness of consumers to price incentives. Increasing the cost of food leads to a contraction in primary production and lower wages of agricultural workers, while stimulating non-agricultural sectors whose products are not taxed. The contraction of primary production generates environmental synergies by reducing land and water use and lowering agricultural GHG emissions.

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