suprema

REPORT #2

AGRICULTURAL POLICY SCENARIO

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Glossary / Acronyms

AGMEMOD	Agricultural Member States Modelling
CAP	Common Agricultural Policy
CAPRI	Common Agricultural Policy Regional Impact
EFA	Ecological Focus Area
EU	European Union
GAEC	Good Agricultural and Environmental Conditions
MITERRA	Miterra-Europe
MS	Member States
MTO	Medium-Term Outlook
NSPS	National Strategic Plans
NUTS	Nomenclature of Territorial Units for Statistics
SOM	Soil Organic Matter
SOS	Safe Operating Space
SUPREMA	Support for Policy Relevant Modelling of Agriculture
SWOT	Strengths, Weaknesses, Opportunities and Threats

1 Introduction

1.1 Objective

This SUPREMA report has a focus on assessing an agricultural policy scenario to explore the prospects for the EU agriculture under different conditions. As will be explained in Section 1.2, for the purpose of this report two variants of the agricultural policy scenario have been modelled by assuming different drivers:

i. Scenario 1: 'Common Agricultural Policy (CAP)' scenario; and
ii. Scenario 2: 'Sustainable diet' scenario.

Both scenarios are hypothetical but have been chosen after several discussions within the project team and in such a way that the can provide insights in future policy issues such as:

i. a further greening of the CAP, which fits naturally in the policy implementation space as it is included in the ongoing policy reform of the CAP after 2020; and
ii. as increasing consumer awareness about healthy diets and their relation to meat consumption, as well as the footprint/climate consequences are highly relevant with respect to the Green Deal roadmap (December 2019) and the Farm to Fork Strategy (May 2020) policy documents that have been recently published.

This set of scenarios have been modelled by means of different modelling tools or different combinations of modelling tools. More specifically, this comparative assessment has involved the following model (combinations): (i) AGMEMOD-MITERRA and (ii) CAPRI. The AGMEMOD- MITERRA tool combines an economic model (AGMEMOD) with a biophysical model (MITERRA), whereas CAPRI is mainly an economic model, with an extensive biophysical representation of EU agriculture.

In addition to the baseline definition and baseline comparison the report focuses on a comparative assessment of scenarios and the insights this offers into the ways in which models deviate from each other with respect to scenario results and into the reasons why this happens. As such, the focus of this report is to provide a proof of principle of the model combinations (including the model linkage work done under the SUPREMA project, see also SUPREMA Report #1) that are used to simulate the agricultural policy scenario. The scope (and budget) of the SUPREMA project does not provide for a detailed CAP scenario assessment, but rather used some illustrative agricultural policy scenarios for modelling tools comparison.

1.2 Preliminary considerations

Initially, it was the plan to do a simulation on the proposed CAP Reform. However, though attractive, it turned out that there were so may open issues at the time the work needed to start, that it was decided to do a more limited exercise. The proposed new CAP leaves a lot of room to the Member States, for implementing CAP measures. In the preparation for the proposed new CAP each Member State has to do a SWOT-analysis with respect to the perceived strengths and weaknesses of the current CAP in the context of the local needs and challenges. When preparing the scenario simulation several (draft) SWOT-analysis have been consulted, but their content was found to be too open and general, to make a reasonable assessment on which policy measures mix and implementation mode specific Member States may select. For example, an interesting case would have been to simulate the impact of the new eco-scheme provision, but information on how this could look like and be structured was still lacking at the time this analysis was prepared. While at the same time the SWOT that we could consult made it likely that Member States will search for specific solutions, implying that simulating generic measure implementation over Member States, as was done in the Commission's ex-ante assessment became less interesting and in no need for a replication.

Whereas the focus of the agricultural policy scenario should be on the CAP, a discussion has started about a food systems approach to agricultural policy. With the Communication on the 'European Green Deal', published by the European Commission (EC) on 11 December 2019 (COM (2019) 640), the President of the European Commission von der Leyen launched the debate on the strategy to become 'the world's first climate-neutral continent by 2050' with the aim of decoupling economic growth from resource use. The ambition of the European Green deal goes beyond just climate policy, aiming for a coherent and holistic policy framework able to deliver decarbonization, sustainability, protection of natural resources and biodiversity together with economic competitiveness. A 'Farm to Fork Strategy' has been published in May 2020,[1] which should further elaborate on implications for EU agriculture and food. One interesting aspect here is the proposed food systems approach, which sees primary agriculture (food production), its footprint, and food consumption and healthy dietary choices as interrelated and subject of sustainability-thinking. Within this context the whole food chain faces the challenge to produce more with less, to decouple growth of output from growth of input. A major transformation of food supply systems is already taking place thanks to new technologies that have the potential to switch the traditional trade-off between productivity and sustainability into a win-win situation. At the same time, there are signs that part of the consumers is actively reflecting on their food consumption styles, especially with respect to animal and vegetable protein consumption. It was decided to devote one of the variants of the agricultural policy scenario to the potential implications of preference shifts at the consumer side for EU agriculture.

1.3 Methodology

It has been agreed that in the scenario assessment the focus will be on understanding the impacts of several drivers on agriculture. Each variant of the agricultural policy scenario will affect the agricultural sector in different ways, therefore, working along different mechanisms. Scenario 1 (the so called 'CAP scenario'), which focuses on exploring different aspects of the CAP, has two types of effects:

i. a budget reduction causing a reduction of payments, including the production-incentive related voluntary income support; and
ii. a change in the ecological focus area, which will imply a change in one of the key inputs (available land) for agricultural production.

The first impact will imply a change in 'effective prices' farmers receive for products subject to voluntary coupled support, by causing a shift along the supply curve (see Figure 1). The second impact will also affect supply as it translates into a shift to the left of supply curves of land-based productions. Whether this would be in general impact due to induced price changes will be explored in Chapter 2.

[1] Further details are available at: https://ec.europa.eu/food/farm2fork_en.

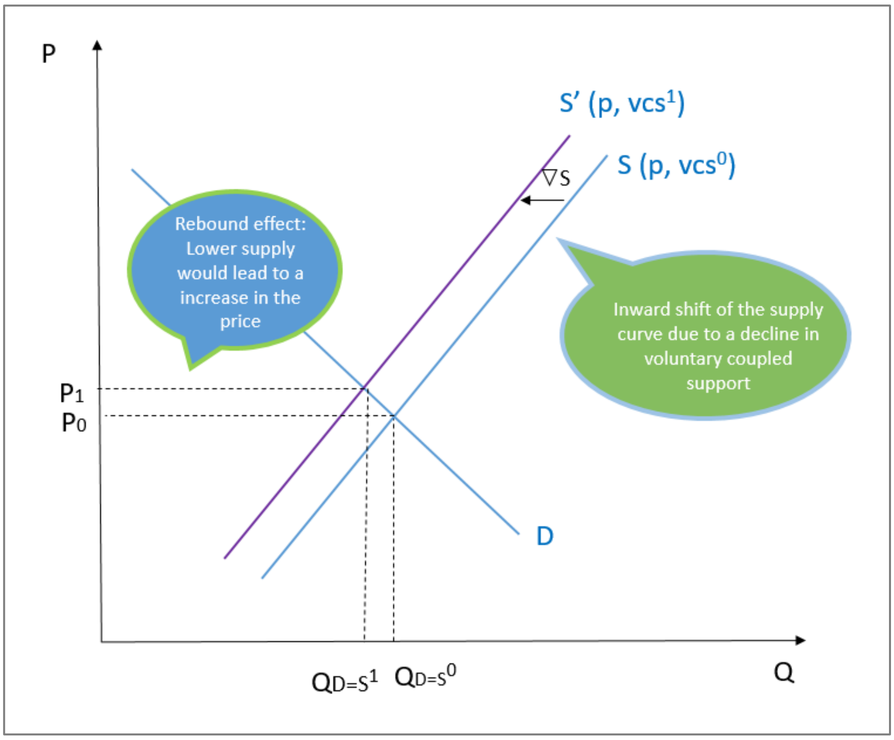

Figure 1. 'CAP' scenario – underlying mechanism
Source(s): Composition by authors.

In Scenario 2 (also referred to as 'Sustainable diet scenario') the impacts are mainly coming from the demand side as the preference shifts with respect to red meats, will have a negative impact on the meat demands (inward shifts of the demand curves). Figure 2 provides more details on the logic of the scenario.

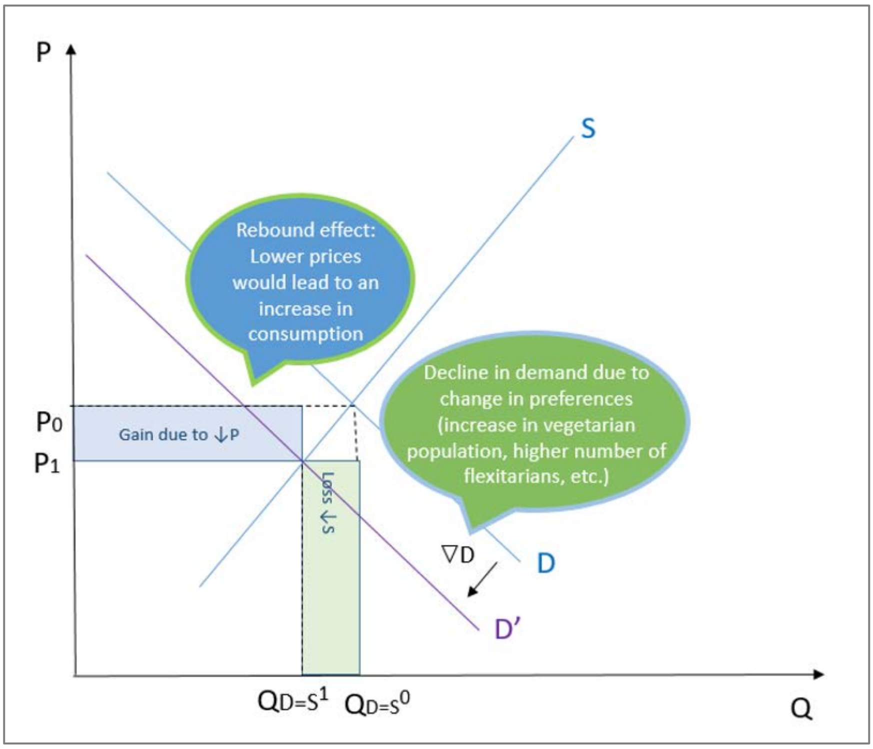

Figure 2. 'Sustainable diet' scenario – underlying mechanism
Source(s): Composition by authors.

The figures are helpful in that they indicate the direction in which a new market or sector equilibrium is likely to evolve. As shown in Figure 1, Scenario 1 is likely to lead to lower supply of crops. However, it should be noted that a reduction in the policy incentive payment (voluntary coupled support) could lead to market prices that could even go up since the scarcity may increase (due to the policy induced supply reduction). For animal products the impact on land is negligible as ecological focus area limits only apply to arable land and not to pasture. However, the policy induced payment decline is likely to negatively affect supply, with observed market prices potentially going up. As indicated in Figure 2, a lower meat consumption at lower prices is likely to result. This will negatively impact on the production of the (targeted) meats.

The figures, indirectly, also illustrate the expected impacts on net trade associated with the simulated policy changes. Under the CAP scenario one would expect net trade to decline as a result of a negative supply shock with a more limited adjustment in demand. For Scenario 2 the expected impact goes in the opposite direction: more agricultural exports as a market outlet for the declined demand for meat products by EU consumers.

1.4 Structure of the report

Further to this introduction, this report is structured in four chapters and one appendix as follows:

- Chapter 2 focuses on the CAP policy scenario, explaining its background and results;
- Chapter 3 elaborates on a sustainable diet scenario or adjusted meat consumption, providing the rationale behind the scenario and discussing its implications in terms of production and climate change;
- Chapter 4 further discusses the results and concludes;
- Chapter 5 presents the reference list; and
- Appendix provides some additional background literature.

Note: This report draws on two scenario's that have been assessed using the CAPRI and AGMEMOD-MITERRA models. Detailed quantitative information on scenario's and simulation results have been uploaded in the (publicly accessible) DataM portal of the EU Commission (JRC Seville). The details reported go much beyond the information that will be discussed here. Interested readers could find more details at the DataM portal. If this is not sufficient, it is always possible to get more specific information, which could then be made available upon request from the authors.

2 The Common Agricultural Policy (CAP)

2.1 The CAP beyond 2020

On 1 June 2018, the European Commission presented legislative proposals on the Common Agricultural Policy (CAP) beyond 2020 (EC Regulation (COM (2018) 392, 393 and 394). These proposals aim to make the CAP more responsive to current and future challenges such as climate change, while continuing to support European farmers for a sustainable and competitive agricultural sector. Discussions between Member States on the new CAP are still in full swing and have been delayed. As a result, the new CAP not likely to enter into force in 2021, but rather in 2022. Member States have to submit their National Strategic Plans (NSPs), which first will have to be discussed in national parliaments, to the EU Commission in 2020. The NSPs allow Member States to tailor their agricultural policies to local needs. Already in the last CAP reform, which relative to the past provided Member States with a number of implementation modalities, it could be observed that different Member States seem to follow different strategies. This is likely to increase since, on the one hand, the flexibility with the proposed new delivery model has been enlarged; while, on the other hand, the policy challenges Member States face may be diverging (e.g. differences in national implications related to satisfying the Paris climate commitments). For the construction of a first CAP scenario it has been decided to focus on the EU budget as well as the greening of the CAP, with the aim to simulate a CAP scenario which 'delivers more (public goods/green services) for less (budget).

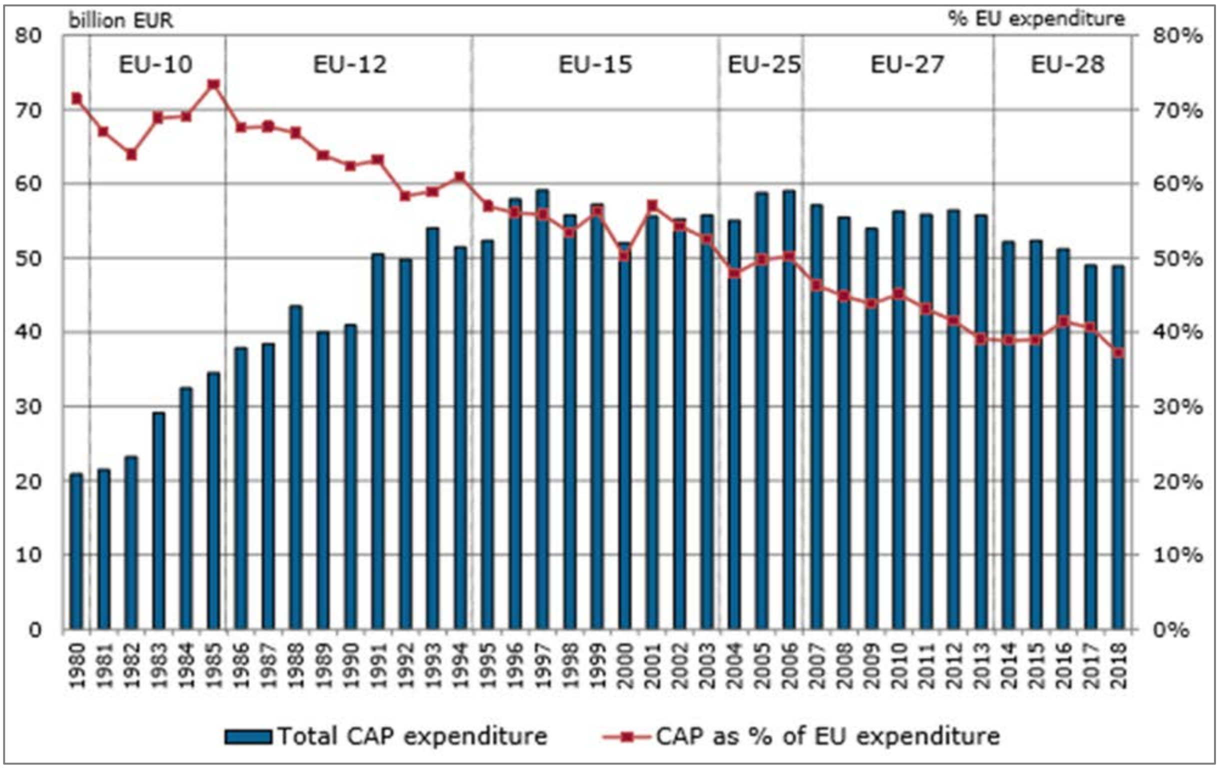

Figure 3. CAP expenditure in total EU expenditure (2011 constant prices)

Source(s): CAP expenditure: European Commission, DG Agriculture and Rural Development (Financial Report). EU expenditure: European Commission, DG-BUDG-2008 EU Budget Financial Report for 1980-1999, DG BUDG-2015 EU Budget Financial Report for 2000. Annual expenditure in 2011 constant prices by applying a 2% yearly constant deflator/inflator.

As Figure 3 shows, the share of CAP spending in EU GDP shows a steady downward trend, irrespective of new policy challenges such as EU enlargements nor the introduction of direct payments.[2] Since 2013 the absolute CAP expenditure also follows a downward trend. In the proposals for the CAP after 2020, the budget that has been proposed amounts to euro 365 billion for period 2021 – 2027 (which is assumed to already account for 12 billion euro gap resulting from Brexit). This comes down to a 5% nominal budget reduction as compared to the current CAP. Moreover, it would imply that the contribution Member States have to make will (on average) exceed the 1% of their GDP-line. In the debate since then, several MS object to cross the 1%-line, and rich MS have reservations to contribute to fill the gap created by the UK. At the same time, the new Commission would like to extent actions (new Green Deal) also to areas outside agriculture. Under the Finish presidency the maximum share of EU payments in GDP has been reduced from 1.17% to 1.11%. Although it can be debated to which extend agriculture will be or not be included in this reduction, it has been assumed that parallel to other sectors, also agriculture will have to face an additional budget reduction of about 4%.

The second aspect of the first CAP scenario regards the greening of EU agriculture. The current greening conditions imply an ecological focus area (EFA) rate of 5% of the agricultural land. The effective average

[2] Since the MacSharry reform (1992) the CAP budget has not increased (in real prices).

rates are lower because of exemptions for small farms (e.g. resulting in an effective rate of about 3%). According to the proposed legislation for the CAP after 2020 the EFA-obligation will be included in the enhanced conditionality (the latter replaces the current cross-compliance conditions). Moreover, eco-schemes have to be developed (at least 1), which provide farmers a hectare payment in return for their fulfilling of certain management practices or their delivery of green services. Farmers are free to adopt an eco-scheme. Unfortunately, at the stage this work took place there was still no information suggesting what eco-schemes Member States would offer to their farmers, and also not about the payments and budgets that would go with these.

Table 1. Enhanced conditionality, choices and eco-schemes at MS level

	GAEC	MAIN OBJECTIVE	CHOICE FOR MS
CLIMATE	1 Maintenance of permanent grassland	General safeguard against conversion to other agricultural uses to preserve carbon stock	Decide on scale of monitoring (share of PG / UAA)
	2 Protection of wet- and peatlands	Protection of carbon rich soils	Designation of areas
	3 Ban on burning stubbles.	Maintenance of SOM and prevent N2O and CH4 emissions	-
WATER	4 Bufferstrips along waterlines	Protection of river courses against pollution and run-off	Requirements concerning width of bufferstrip and type of water course
	5 Use of farm nutrient tool	Sustainable management of nutrients	Decide on which tool to be used
SOIL	6 Tillage management reducing risk of soil degradation	Minimal land management to limit erosion	Specify conditions for soil management and areas concerned
	7 No bare soil during sensitive periods	Soil protection	Specify management requirements
	8 Crop rotation	Maintenance of soil fertility and SOM	Specify management requirements
BIODIVERSITY	9 Minimum share of unfarmed features / landscape elements	Maintenance of non-productive elements and maintenance of SOM	Decide on minimal share of unfarmed features
	10 Ban on ploughing / converting permanent grassland in N2k areas	Protection of habitats and species	Decide on areas concerned (N2k +)

Source(s): Table based on draft legislative proposal COM (2018) 392, final

For the scenario setting it has therefore been assumed that the EFA's will be part of the enhanced conditionality and a generic (effective) 5% level will apply. In addition, Member States should impose eco-schemes. It has been assumed that they will offer extended buffer zones (see GAEC 4), and/or and 'maintenance of non-productive elements' (see GAEC 9) which will lead to an additional 2% of land which can be counted as EFA-area (see Table 1). As such, the expected net-effect is an increase of the (effective) EFA area from about 3% to 7% (or a change of +4% to the current values used in the models). Due to lack of information no further regional/MS differentiation is assumed. Note, however, that when applying the proposed +4% of EFA-area as a change on top of the current (effective) EFA percentage, the implicit heterogeneity is already to some extent taken into account. What will not be accounted for is that Member States may in practice follow different implementation modes with respect to the design and implementation of greening measures. Note that it has been assumed that the provided eco-schemes will lead to a sufficient adoption (induced by targeted payments) to achieve an additional 4 percentage point EFA increase.

2.2 Scenario Assumptions

For the simulation of the first CAP scenario some further scenario assumptions have been made. The new CAP is assumed to start in 2023. So the year 2023 will be the starting year for implementation of the shocks/measures. A budget reduction of 9% (= 5% + 4% added) will be imposed, which applies linearly to all direct payments, including voluntary coupled support. The EFA rate is assumed to increase by 4% on top of its current (effective) applications rate.

A first estimate of the expected impacts can be derived using the reasoning form economic theory:

- The market impacts of the budget reduction will in particular take place as a supply response to the change in the support coupled to production, viz the adjustment of the voluntary coupled support rates. This will have a negative impact on the supply of products with coupled support. As supply responses are generally price inelastic the supply decline is expected to be less than proportional to the 'effective price' (= market price + voluntary coupled support amount per unit of product) change.
- An increase in the effective EFA rate will reduce the availability of agricultural land, which would also lead to a reduction in agricultural supply. As it is most likely farmers will take relatively low productive (or marginal) land out of production, also here a less then proportional supply reduction is expected. Because in several Member States there is still idled land beyond the level required for satisfying the current EFA-rates, there may be some 'redundancy', which would further lower the impacts on production.

As the main aim of the CAP scenario simulation is to provide a proof of principle and on a comparison of results coming from two different models or model combinations, only a selected set of results will be presented and discussed. The selection has been chosen in such a way that key variables are discussed. Since for the first CAP scenario sectors where voluntary support measures apply are likely to be affected and aside from animal productions including a crop sector would be relevant to capture land change effects a selection has been made to focus on beef and dairy and sugar beet. The beef and dairy sectors are receiving a large share of voluntary coupled support payments. In a subset of Member States also sugar beet production is supported by voluntary coupled support payments.

2.3 Key findings

2.3.1 Production

Table 2 provides a comparison between AGMEMOD and CAPRI of some selected production figures. The outcomes of both follow the expected direction (see Section 1.3). In general, the impacts found are quite limited. This seems plausible as the simulated budget reduction implies a reduction in farm payments, which are however largely decoupled from production. However, for the selected products, these are in many cases (variation by Member State) also subject to voluntary coupled support, which creates an incentive-link with respect to a budget change, as this will affect the envelope available for voluntary coupled support. The simultaneously simulated increase in ecological focus area is expected to negatively affect the available crop land, and which will especially impact the sugar beet crop (arable land competition). Looking to the general results found and taking into account the importance of direct and coupled payments for especially the beef sector, both models might underestimate the potential impact of the simulated coupled payment reduction. A complication here is that implementation modes of the coupled (and direct) payments vary by Member States and can be rather complex (e.g. allowing for payment differentiation depending on herd size/ number of animals). Moreover, in case of 'over application' the payment rates maybe 'endogenously' reduced for ensuring the total amount of payments claimed/made to satisfy the maximum budget available from the envelope. Capturing all these details of the policy representations clearly provides a challenge to both models (has been confirmed by expert comments).

When comparing AGMEMOD and CAPRI results AGMEMOD turns out to show a much lower responsiveness of production relative to CAPRI. There are three key factors contributing to the found differences:

- The impact of a change in coupled support on product supply depends on the effective price elasticities prevailing in both models. In AGMEMOD these are much smaller than in CAPRI. CAPRI uses a supply optimization module maximizing farmers' profits and has for that reason quite some flexibility to change the land and crop mix allocation as a response to financial incentives[3]. In AGMEMOD the response elasticities to direct payment are based on econometric estimation, taking into account historical data, which in general lead to low (effective) price responsiveness.
- The AGMEMOD model uses a slippage factor with respect to the set-aside of land, which implies that it accounts for the fact that the most marginal lands will be used to satisfy ecological focus area requirements. As such the decline in production will be less that proportional than the reduction in land.
- Moreover, the slippage factor can run high as Member States have still 'reserves' of idled land, which is currently not used to satisfy the current ecological focus area restriction (which plays a significant role in explaining the obtained AGMEMOD results).

Table 2. Production at EU level (% deviation from baseline in 2030) – Scenario 1

	AGEMOD	CAPRI
Beef	-0.02	-0.22
Dairy	-0.04	-0.10
Sugar	-0.01	-0.92

Source(s): AGMEMOD and CAPRI.

[3] In the CAPRI model, elasticities are taken from other studies but also partially calibrated inside the model. In AGMEMOD, elasticities are implicit in the behavioural equations that form the model. AGMEMOD's equations very often include a lag of the relevant price variable and/or a lag of the dependent variable – they are dynamic elasticities with different time horizons. Although the comparison of the elasticities between the two models is possible, carrying out that exercise is not so straight-forward since it requires several additional assumptions to translate the elasticities into ones that have a common reference period. This complex exercise goes beyond the scope of the project and therefore it was not included in the deliverable. It should be further noted that the observed responses are a result of elasticities and multiple variables that are simultaneously changing (e.g. own prices and cross-prices and several simultaneous shocks in policy variables). These (partial) equilibrium-elasticities are likely to differ from the standard (single equation) elasticities (see Thurman, 1991).

2.3.2 Net trade

As the results on production are quite limited (see previous section) also the impact on EU net trade will be limited. But because the net trade is only a fraction of EU production or consumption, already small changes in these aggregates can show a more than proportional impact on net trade flows. This is shown from Table 3, where the absolute percentages change for net trade are larger than the percentage changes obtained for production. In general, the (small) reductions in production should lead to a (small) lowering of the EU's self-sufficiency rates. Ass such one would expect either EU net imports to increase of its net exports to decline. This is what is shown in Table 3. A factor causing differences between AGMEMOD and CAPRI here is that in the AGMEMOD model the self-sufficiency rate-variable is a factor affecting EU-world market (key) price transmission, whereas in CAPRI bilateral trade flows are modelled.

Table 3. Net trade at EU level (% deviation from baseline in 2030) – Scenario 1

	AGEMOD	CAPRI
Beef	-0.31	-3.91
Dairy	-0.13	-0.05
Sugar	0.00	-7.09

Source(s): AGMEMOD and CAPRI.

2.3.3 Consumption per capita

The changes in consumption are likely to be small, as it was already observed (see Table 2) that the impacts on production are in general very limited. This also leads to small induced price changes (see Table 5 in the next section). As expected, consumption is reacting in a negative way on price increases and the other way around.

Table 4. Consumption per capita EU28 (% deviation from baseline in 2030) – Scenario 1

	AGEMOD	CAPRI
Beef	-0.00	-0.10
Dairy	-0.00	-0.01
Sugar	-0.01	-0.00

Source(s): AGMEMOD and CAPRI.

2.3.4 Price developments

As has been argued before (see Section 1.3) for directly affected products a positive net impact on prices is expected. This is also what is confirmed by the CAPRI model, although the observed price increases are in all cases very small. AGMEMOD has even smaller price changes, which vary around zero. Given the lower impact on production figures (cf. Table 2), these deviations from the CAPRI results are not surprising. An observation is that the price changes reported by AGMEMOD do not satisfy the general hypothesis as 2 out of the 3 price changes are negative (although hardly different from zero). This could be a result of the structure of substitution patterns between meat and dairy products as these are implicit the AGMEMOD's demand module, as well as from rounding errors in the model solver routine (precision factor).

Table 5. Average price EU28 (% deviation from baseline in 2030) – Scenario 1

	AGEMOD	CAPRI
Beef	-0.01	0.41
Dairy	0.03	0.07
Sugar	-0.08	0.07

Source(s): AGMEMOD and CAPRI.

2.3.5 Additional indicators

In this section insights from some additional indicators are provided. As changes in the budget will not only change the voluntary coupled support, but also the direct payments, of which it is known that they can make a substantial part of farm income, it is interesting to also assess the impacts on farm income-indicators. Since only the CAPRI model has a well-running farm income module (in AGMEMOD a module is still under construction) only the CAPRI results are presented here (see Table 6). Again, a selection of results has been made (focus on the crop sector). The impacts on farm income per hectare are in the range of -0.5 to -2.5 percent, with sugar beet being an exception (close to -20 percent). As regards sugar beets the voluntary coupled support payment is a factor here which adds to the negative income effect. Most other crops reported are not subject to voluntary coupled support. The results confirm that although the market impacts from a reduction in payments (see discussions in previous sections) may be limited, the impacts on income per hectare could be still of a much larger magnitude. This confirms the important role of direct payments as providing an income transfer to EU farmers.

Table 6. Additional indicators EU28 (% deviation from baseline in 2030) – Scenario 1

	INCOME PER HA	AREA
Utilised agricultural area	-2.07	-0.40
Cereals	-2.04	-0.76
Oilseeds	-1.83	-0.42
Pulses	-2.57	-0.33
Potatoes	-0.75	-0.09
Sugar beet	-19.87	-1.04
Vegetables and permanent crops	-0.36	-0.09

Source(s): CAPRI.

Figure 4 provides a more detailed regionalization of the per hectare income impacts in a EU-map form. As this figure shows there is a lot of heterogeneity in the EU with respect to agricultural production and the extent to which policy changes affect farm profitability. This is not only the case at Member State level, but also at lower regional disaggregation levels, e.g. NUTS-1, or 'higher' NUTS-levels. The purpose of having this type of map is to illustrate the potential of the CAPRI system and the linked AGMEMOD-MITERRA models to provide insights at regional level that go beyond the MS results that are delivered when using AGMEMOD individually (see also Figure 5 below).

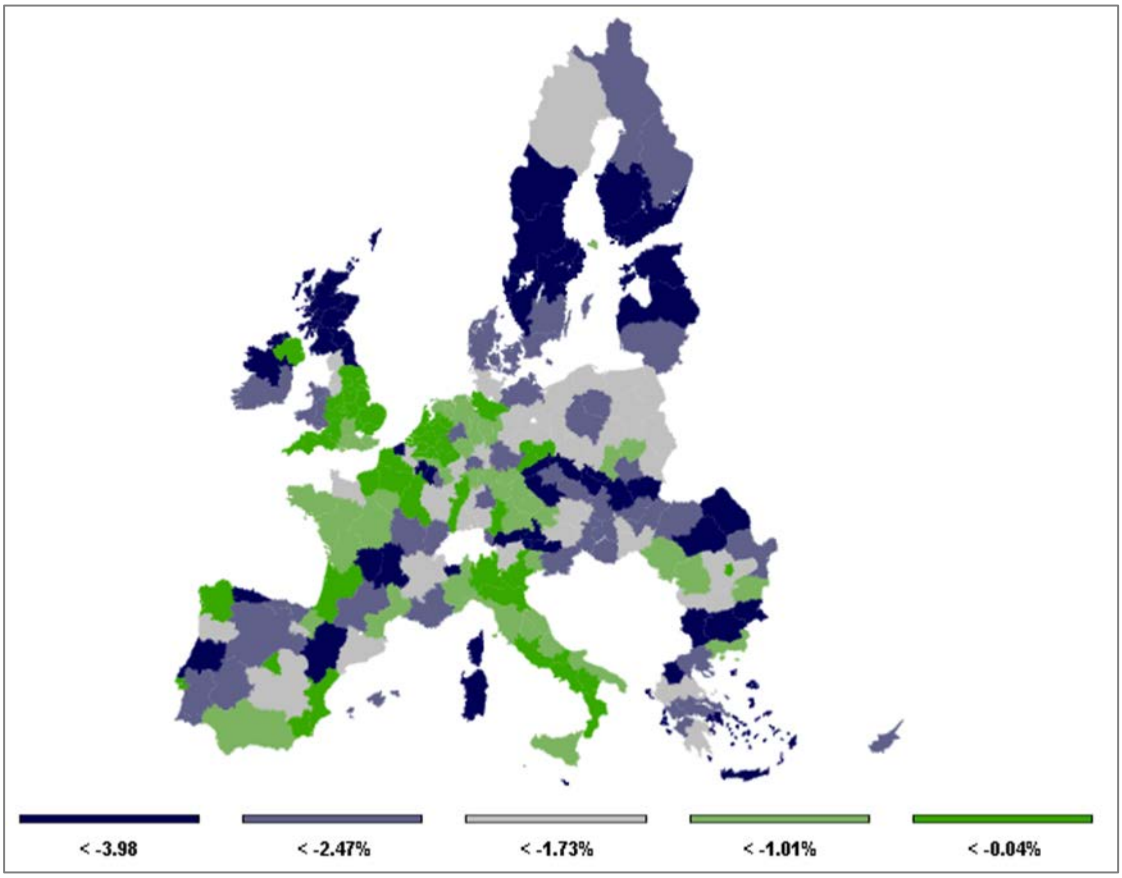

Figure 4. Income per hectare (% change from baseline 2030) – Scenario 1
Source(s): CAPRI.

2.3.6 Environmental impacts

One of the important results from the SUPREMA project is the linkage of the economic model AGMEMOD with the biophysical model MITERRA. The CAPRI model, which started as an economic model, has over time evolved into a model which already captures many agri-environmental impacts. As part of the proof of principle with respect to the model comparison effort it is therefore relevant to compare different environmental emission indicators from both model combinations. Table 7 summarizes the impacts for seven environmental indicators. Both models show changes in similar directions: the CAP scenario leads to a net reduction in crop/animal product output, which has a negative impact on environmental emissions. As in the case of production (see Table 2) the impacts are quite small, with those of the AGMEMOD-MITERRA model being smaller than the CAPRI ones. This reflects the fact that MITERRA 'borrows' its farm-behavioural part (e.g. responses to market and policy signals) from the AGMEMOD model. The model results confirm that an increase in the ecological focus areas and/or reduction in (especially) coupled direct payments can contribute to EU sustainability (ammonia and N-leaching), biodiversity (ammonia), and climate (CH_4, N_2O, greenhouse gas) objectives.

Table 7. Emissions EU28 (% deviation from baseline in 2030) – Scenario 1

	MITERRA-Europe	CAPRI
CH_4 emissions	-0.06	-0.20
N_2O emissions	-0.20	-0.33
GHG emissions	-0.14	-0.24
NH_3 emissions	-0.09	-0.19
N leaching	-0.22	-0.20

Source(s): MITERRA-Europe and CAPRI.

In order to illustrate the spatial detail from results that can be obtained on the biophysical domain from the AGMEMOD-MITERRA model combination, a map of the changes in greenhouse gases is provided in Figure 5 (see also comments made with respect to Figure 4 above). Without going into all the details, an interesting additional insight results from Figure 5. It not only reinforces an earlier statement made about the heterogeneity in EU agriculture, but it also emphasises the importance of substitution effects. The simulated CAP scenario is affecting different agricultural activities in different ways. As an example, the reductions in dairy and beef production may lead to changes in land use and or expansions of other productions (e.g. pigs, poultry, sheep). Moreover, there may be different impacts on the feed and nutrient sourcing. This could lead to a net reduction as well to net increases in the amount of (equivalent) greenhouse gas emissions per hectare. For orange and red coloured regions, the amount of greenhouse gasses shows a net increase. As such these results emphasize the importance of pursuing environmental, biodiversity and climate policies in a targeted way. Moreover, it underscores the importance to take into account potential impacts of substitution in animal productions and land use changes when evaluating the (net) impact of such policies as spill-over effects (indirect effects) can make a difference.

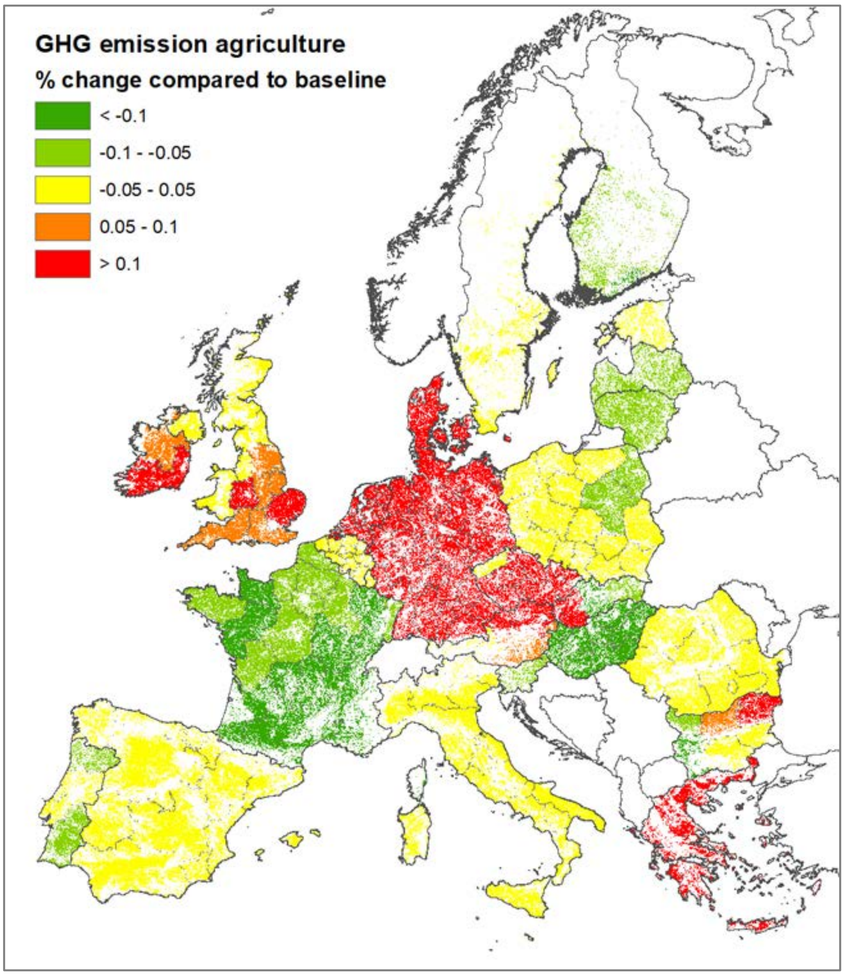

Figure 5. GHG emission agriculture (% change compared to baseline) – Scenario 1
Source(s): MITERRA-Europe.

3 Climate change, healthy diets and the role of meat consumption

3.1 Background

Macroeconomic drivers such as urbanisation, population growth and rising income have played an important role in the increase of meat consumption that was observed in the past. However, the 'picture' at global level still shows important disparities across regions. While these drivers have placed meat consumption into an unsustainable position in the case of developed countries,[4] daily animal protein intake is still below the recommended level in many developing economies. Drawing attention to developed countries, public health and climate concerns are important issues that could benefit from a reduction in meat consumption. Focusing on the European case, a recent report by the RISE Foundation (RISE, 2018) highlights that a dietary change should be a priority within the EU since livestock consumption and production are not in their Safe Operating Space (SOS).[5] Transitioning towards a plant-based diet is a multi-dimensional phenomenon that requires the engagement of the public sector, all actors involved in the supply chain and consumers. In the same vein, the benefits associated to the protein transition will not be limited to the improvement of public health.[6] Reductions in CO_2 emissions and acidification of soil and air, improvements in the sustainability of food systems, as well as potential creation of value added for arable farmers can be expected. Therefore, this dietary shift is a key pillar for a successful transition towards a circular economy.[7]

Box 1. Defining the SOS for the European livestock sector

According to a study of the RISE foundation, the quantification of the lower and upper bounds for the livestock sector at MS level suggests the following changes with respect to current levels:

- Dietary lower bound in two-thirds of MS should be around 80% of current consumption for eggs and 80% to 90% for milk;
- For most MS, fewer ruminant livestock should utilise permanent pasture – 14 MS could justify between 30-60% of current livestock units;
- To meet emissions goals (Paris Agreement) set for 2050, all MS must reduce livestock emissions by between 37% (Bulgaria) and 82% (Cyprus); and
- With regards to N fixation, a 65% reduction of the fixation would be required at EU level – this implies individual reductions ranging 35% (the Netherlands) to 90% (Ireland).

Whereas different arguments can be raised on how to define sustainability criteria for the EU livestock sector, as well on the ways how to achieve these criteria, the RISE study emphasizes the need for the EU in making further steps with respect to improving the long-run sustainability of its agriculture.
Source: RISE (2018).

[4] On average, protein consumption is 37% higher than the recommended intake (0.8 grams/kg/day).

[5] RISE (2018) explores the definition of the EU livestock SOS by using lower boundaries for human nutrition and pasture utilisation and upper boundaries for GHG emissions and nitrogen flows.

[6] Diets that incorporate more plant protein such as pulses and soy are healthier and more sustainable than the 'standard' diet in the EU (Donau Soja Association Report 'The European Protein Transition').

[7] At EU level, the European Commission launched in 2018 a policy document to support the development of plant proteins. Additional information on the 'EU Protein Strategy' is available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0757.

With regard to the 'tools' available to support this preference shift, the following alternatives are at hand: (i) media campaigns to raise awareness on health and climate concerns associated to meat consumption/production; (ii) implementation of production quotas at farm/Member State level; and (iii) implementation of a 'meat tax' that could operate similarly as a 'sugar' or 'fat' tax. Drawing attention to food policy, some research in the case of the UK suggests that a tax that increases red meat prices by 14% and processed meat prices by 79% would be effective in preventing around 22% of deaths associated to diseases like cancer, heart disease, stroke and Type 2 diabetes (Springmann et al., 2018). Another country in which efforts for shifting diets towards more sustainable ones are in place is the Netherlands. In particular, the 'Prevention Agreement' aims at achieving a reduction in the percentage of overweight young people and adults, as well as a decrease in the number of Dutch people suffering from obesity-related diseases by 2040.

Coming back to the production side, EU livestock production has a strong focus on meeting the needs of the domestic market (Figure 6). This self-sufficiency is reflecting the existing import protection, as well as the fact that the system is not competitive in prices due high production costs (compared to countries like Brazil). This already 'high' production costs could increase even more in the coming years in order to comply with upcoming environmental regulation and increase animal welfare. Therefore, the future production of the sector is closely linked to European consumption since there is very limited scope to direct European meat products to the international market.

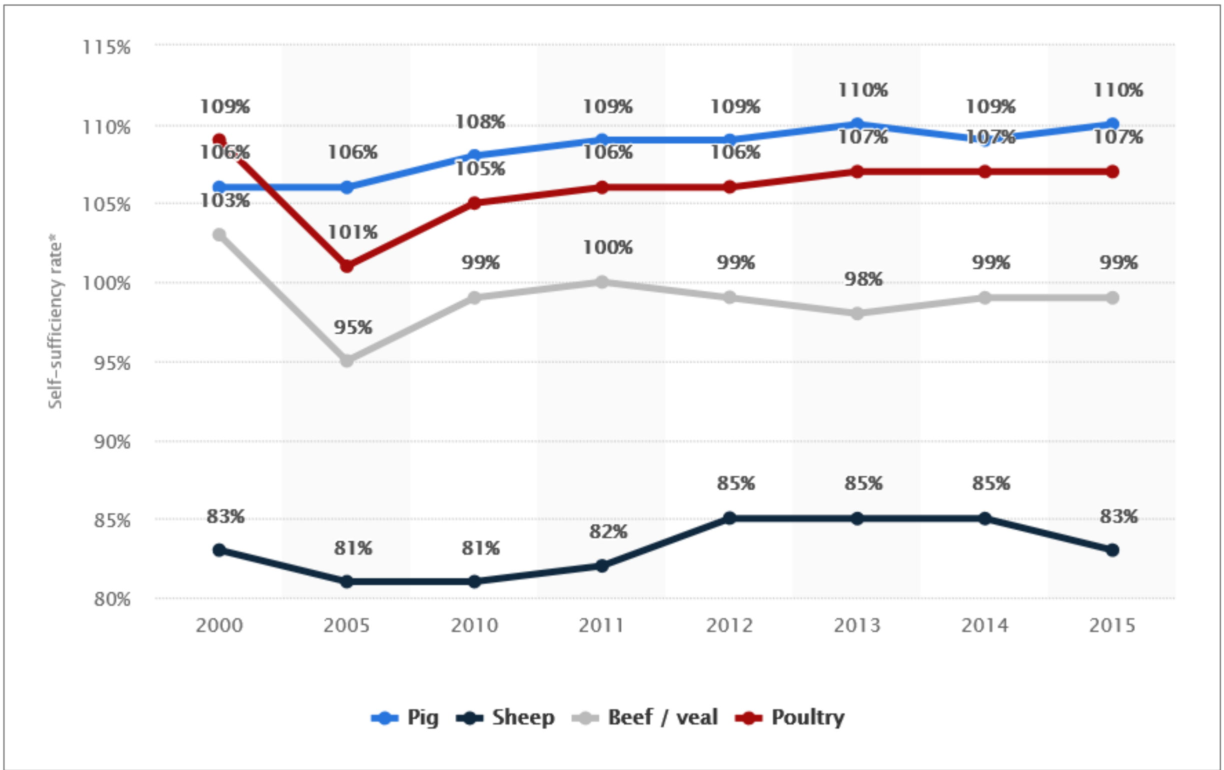

Figure 6. Meat self-sufficiency rate in the European Union (EU-28), by type of meat (2000-2015)
Source(s): Reproduced from Statista (2019).

Keeping in mind this background in which uncertainty regarding the speed of the transition is a central piece, the simulation of scenarios that explore alternative paths of dietary changes is recommended to support the policy-making process. The modelling of 'realistic' scenarios should rely on gradual adjustments in consumer behaviour since previous experiences of 'curbing' the consumption of other products such as tobacco or sugar reveals that 'disruptive' changes cannot be expected.

3.2 Current Trends and Prospects for the Future

Over the past two decades demand for meat has been increasingly growing mainly driven by the development of emerging economies. During this period, global meat demand grew from 209 million tons in 2000 to 270 million tons in 2011 (1.3 times), while population increased at a slower path (1.1 times). This growing demand has had important repercussions on the demand for feed grain, which has been increasing as well (Mitsui Global Strategic Studies, 2016). Nevertheless, meat consumption is expected to peak at a certain level for which needs are satisfied and other concerns regarding health, society or animal welfare start to play a role.

When looking at consumer preferences, more than half of consumers in developed countries are willing to pay higher prices for acquiring products that are delivered by companies which are committed with social and environmental justice (Accenture, 2017). Another example of how environmental concerns can affect consumers demand is the 'Week zonder vlees' campaign that was recently launched in the Netherlands to reduce meat consumption. In this case, 40% of consumers who participated joined the campaign due to environmental reasons, while 34% of participants joined to support animal welfare (Boerdam, 2018).[8] Moreover, in the case of developed countries an increase in the number of vegans, vegetarian and flexitarians has been observed in the recent past. However, this increase has slowed down in some cases after reaching 20% (Future of meat, 2018).

For a better illustration of meat consumption trends, as well as the disparities across broad World regions, Figure 7 reports meat consumption levels since 1960s. At global level, an increasing trend is projected for the period ending in 2050.

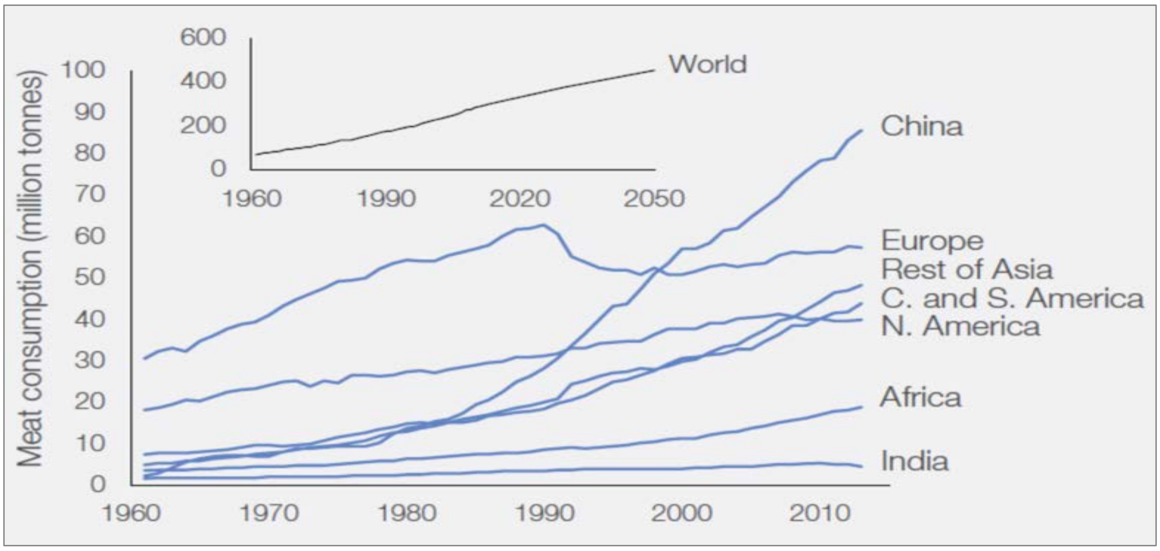

Figure 7. Trends in consumption of meat and prospects to 2050
Source(s): Reproduced from World Economic Forum (2019).

Focusing on the EU market (Figures 8 and 9), a distinction should be made between the EU-15 and the EU-N13 since they show different dynamics. Looking at consumption per capita, it is expected that the gap between the two regions will be narrowing over time, reaching almost similar levels by 2030. Moreover, per capita meat consumption for the EU as a whole has been quite stable approaching 70

[8] At consumer level, the main reasons to reduce meat consumption are health concerns, animal welfare and environment.

kg/capita (equivalent to about 190gr/day and more than two times the global meat consumption level) and is projected to show a limited downward trend for the future.

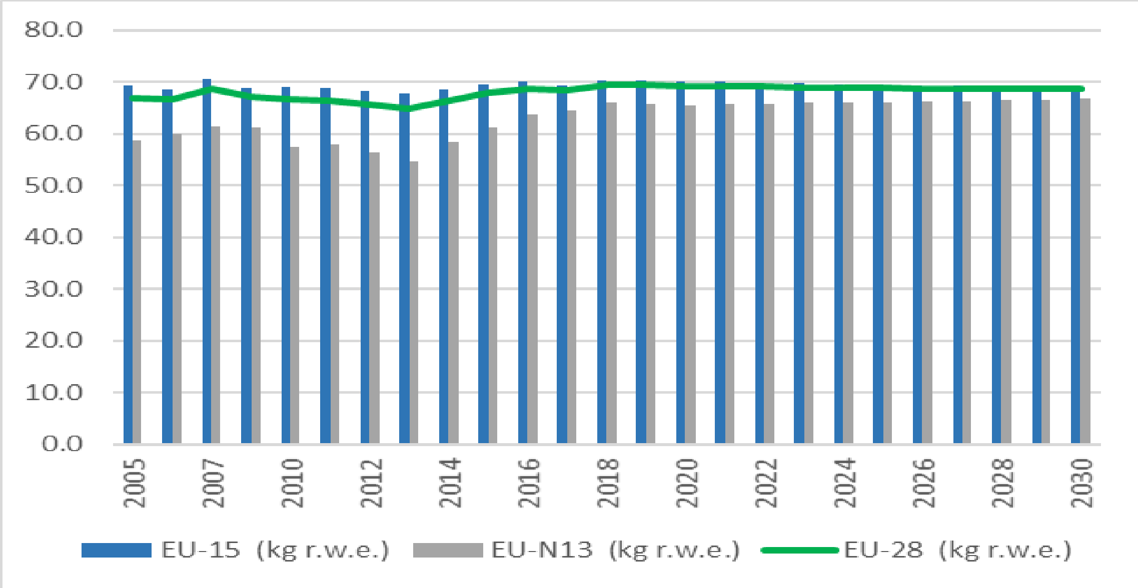

Figure 8. EU Meat consumption per capita, (2005-2030)

Source(s): Authors based on MTO Outlook. Available at: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term.

With regard to production, there are substantial differences between the two broad European regions, representing the EU-15 production around 80-85% of the European total. According to the MTO, no changes in the relative position of the European economies are expected.

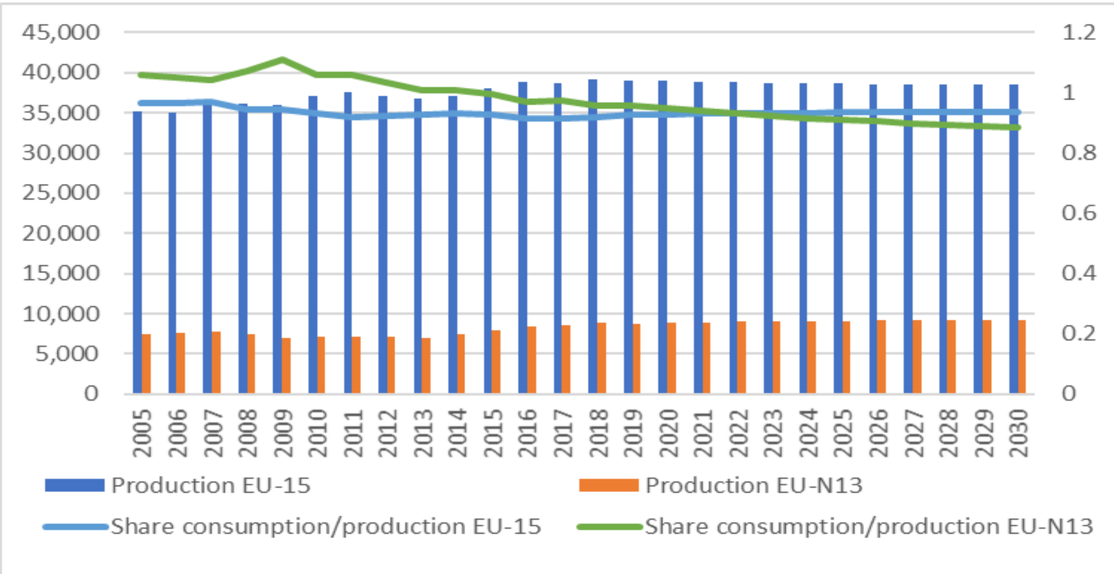

Figure 9. EU production and consumption, (2005-2030)

Source(s): Authors based on MTO. Available at: https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term.

Note (s): The shares reported in Figure 4 are calculated as the ratio total consumption-to-total production in the region (EU-15 or EU-N13).

3.3 Scenario Assumptions

FAO (2013) provides an indication about spatial variation in EU meat consumption (see, Figure 10). Note that these data exclude fish and other seafood and that the figures do not account for waste at household level. Austria and Spain appear to have the highest meat consumption levels. Moreover, consumption levels in the West of the EU tend to be higher than those in the Eastern part.

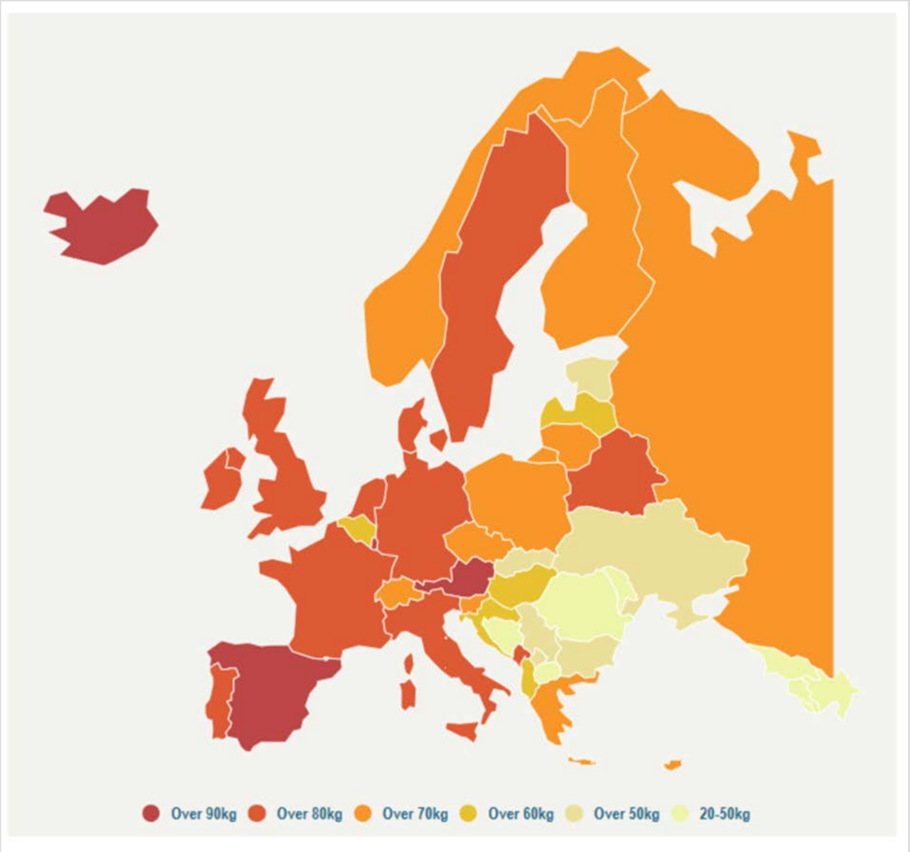

Figure 10. 'Mapping' EU meat consumption (Kg/capita)
Source(s): Reproduced from FAO (2013).

When looking to supply-utilization balances some interesting changes can be observed. Red meat consumption is already declining in a significant number of MS, but patterns are varying. During the last decade, on average in the EU annual reductions pork and beef of 130 gr/yr and 110gr/yr were observed respectively (measured in terms of apparent cons). Table 8 provides a more detailed assessment showing the regional variation between Member States as well as the observed main trends for both key red meat types (pork and beef). As shown in the table, the number of Member States with an increasing trend in per capita consumption during the period 2008-2018 has been limited to about 11 Member States, with a differentiation by product.

Table 8. Red meat (apparent) consumption trends in EU, 2008-2018

RED MEAT TYPE	DECREASING CONS/CAP	STAGNANT CONS/CAP	INCREASING CONS/CAP	COMMENTS
Pig meat	AT, BE, CZ, DK, FR, DE, GR, IE, IT, NL, SK, NL?, SK, SL, SW	FI, HU, PL, UK, CY, MT	HR?, EE, LV, LT, PT, RO, ES	-3% (-0.32% per annum)

				From current 39.4kg/c to 38.1kg/c
Beef	BE, EE, FI, FR, GR, IT, LT, MT, PL, RO, SL, SW, UK, MT, CY	AT, BG, HR, DK, LV, NL, PT, ES	DE, HU, IE, SK	-7% (-0.73% per annum) From current 15.0kg/c to 13.9kg/c

Source(s): Composition by authors from Eurostat data.

Table 9 supplements Table 8 by providing additional information on the consumption levels, with the aim to identify whether there is a linkage between consumption levels and the trends in consumption. Member States have been classified into three categories: below EU average; around EU average, and above EU average. There is no simple linkage between the level of meat consumption and the observed trends. This implies that alongside issues such a achieving a certain level of wealth (and associated meat consumption) also other factors, such a social and cultural preferences matter.

Table 9. Comparison red meat (apparent) consumption patterns in EU, 2008-2018

RED MEAT TYPE	BELOW AVERAGE	AROUND AVERAGE	ABOVE AVERAGE	AVERAGE 2008-2018
Pig meat	BG, FI, FR, GR, IE, EE, RO, SK, SW, UK, SI, MT	NL, IT, LV	AT,BE, HR, CZ, DK, DE, HU, LT, PL, PT, ES, CY	40.5kg/c
Beef	BG, CZ, EE, HU, LV, LT, PL, RO, SK, CY	HR, DE, ES	AT,BE, DK, FI, FR, GR, IE, IT, NL, PT, SI, SW, UK, MT	14.2kg/c

Source(s): Composition by authors from Eurostat data.

In order to get a better insight into preference formation with respect to meat consumption a further assessment has been made into estimating the number of people that are/have become vegetarian (no meat consumption at all) and those consumers which have become flexitarians (people which have regular meet-free days). Information on the share of vegetarians at MS level was not readily available. Therefore, preliminary estimates have been made using a variety of (often anecdotal) sources. The results of this exercise are presented in Figure 8. As shown in Figure 11, the share of vegetarians in 2018 is estimated to be the highest in Germany (about 11% of the population), while countries like Bulgaria and Romania are at the lower end, having rates of 1 percent or less.

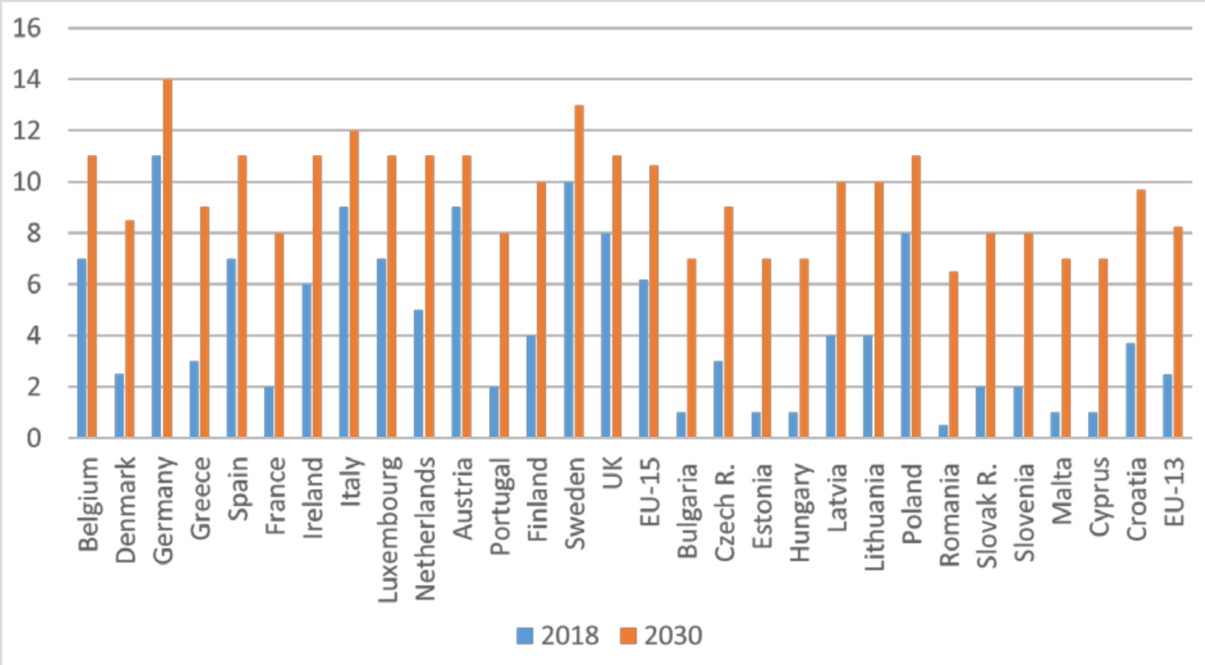

Figure 11. Share (%) of vegetarian and vegan population (2018 vs 2030)
Source: Composition by authors from various sources and missing information filled by expert estimates.

For the scenario development some assumptions have been made about how the number of vegetarians could further increase in the coming decade. It has been assumed that there will be:

- Slow adjustment (0.25% increase/annum) in countries with already a high share of vegetarians (DE, SW, AU, IT, PL); and
- A stronger increase (0.50% increase/annum) in countries have a relative low share of vegetarians (all other EU MS).

These assumptions imply that in 2030 the MS-average share of vegetarians would increase in the EU-15 from about 6% to 10.5% (+4.5%), while in the EU-13 it increases from 2.5% till about 8% (+5.5%) (see Figure 9 for Member State details). No changes after 2030 are considered. With respect to the consumers that are meat consumers some assumptions have been made to capture potential movements into a more flexitarian type of lifestyle. Unfortunately, no data on flexitarian-patterns was available at EU MS level, except for some fragmented anecdotal evidence. As a second-best solution, therefore, it has been decided to then rely on existing consumption patterns and extend these in a stylized way into the future, based on specific assumptions. A differentiation has been assumed according to observed trends as they were already discussed before. More precisely it has been assumed that, with respect to red meat consumption (pork and beef):

- Member States with below average consumption follow their current trend;
- Member States with above average consumption will decline red meat consumption per capita by 1.0% per annum; and
- Member States with average meat consumption will decline read meat consumption by half the amount of 'above', or by 0.5% per annum.

Figure 12 comprises the percentage changes in per capita consumption for beef and pork over the period 2018-2030, resulting from applying the assumptions mentioned above. Note that Figure 12 shows the combined effect: (i) increase in vegetarian population; and (ii) per capita decline due to flexitarians. Note that as a general rule it has been assumed that the total effect of vegetarian and flexitarian increase would never make the maximum per annum rate of adjustment in (equivalent) per capita (apparent) consumption to exceed 2 percent.

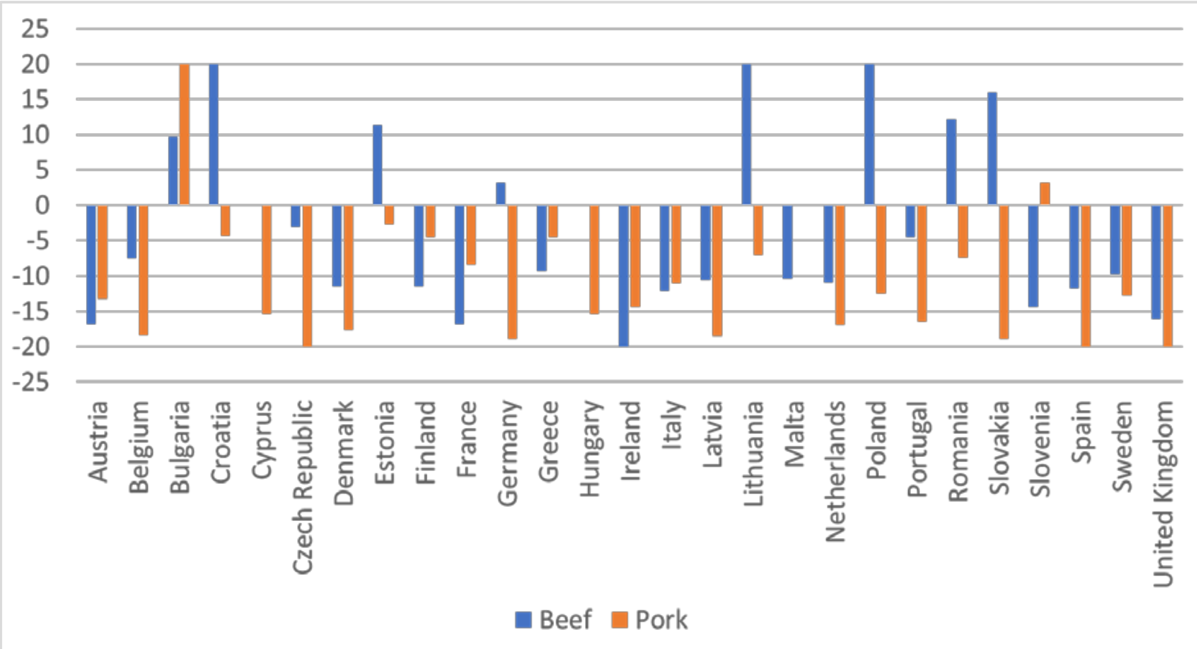

Figure 12. Changes (%) in consumption per capita (2018 vs 2030)

Source: Authors' calculations.

The decline in red meat consumption observed during the past decade has been partly 'compensated' by increases in poultry meat and dairy products, e.g. by the increasing trend in white meat/poultry consumption per capita. These (existing) patterns have been simply extended into the future. It is important to note that no explicit assumptions have been made with respect to the compensation by poultry and dairy products (existing development is assumed to continue unchanged). The already existing trends (for poultry, sheep meat and dairy products consumption) have been taken for granted. Consumption shocks are assumed to start in 2020.

3.4 Key findings

3.4.1 Production

This section presents an overview of the impacts of a consumers' preference shift at EU level that results in a larger share of the population adopting vegan, vegetarian and flexitarian consumption habits. As was already explained in Figure 2, this meat preference shift has two impacts: (i) a direct consumption impact, i.e. consumers reduce their animal protein intake which leads to lower prices due to a decline in demand; and ii) a price effect, i.e. the is a 'rebound' effect since some consumers might find in lower meat prices a motivation to increase their consumption since animal products improves their affordability.

As shown in Table 10, the results of the CAPRI simulation point to a similar response in production in the case of beef and pork meat. However, the outcomes of the modelling in AGMEMOD suggest marginal changes compared to the baseline in the case of beef and poultry production level. A decline of about 5 percent is projected in the case of pork production. In general terms, market reactions are mainly driven by prices changes (see, Section 3.4.4 for additional comments on the impacts on production). Therefore, the expected (negative) impacts on farm revenue are stronger than on farm sales. In understanding the outcomes (and differences between them) it is also important to look not only to the direct effects of the modelled policy shocks, but also account for their indirect effects (spill-overs between markets, substitution patterns)[9].

Table 10. Production at EU level (% deviation from baseline in 2030) – Scenario 2

	AGEMOD	CAPRI
Beef	-0.32	-3.44
Pork	-4.98	-3.80
Poultry	0.04	-0.30

Source: AGMEMOD and CAPRI.

3.4.2 Net trade

As explained in Section 3.1, the EU meat sector has a strong domestic focus. Therefore, the outcomes in terms of net trade are strongly driven by the decline in domestic consumption that is expected at EU level. In the case of pork there is also a decline in production that is playing a role as simulated by both models. The outcomes of the modelling suggest an increase of net exports in the case of all meats, which is in accordance with expectations from theory (see Section 1.3). Although there are strong differences across sectors, being the largest impact calculated is in the case of beef, as demonstrated by both models. As mentioned in the case of Scenario 1, the difference between the two models can be explained by the role of the self-sufficiency rate-variable that affects the EU-world market (key) price transmission in the case of AGMEMOD.

Table 11. Net trade at EU level (% deviation from baseline in 2030) – Scenario 2

	AGEMOD	CAPRI
Beef	177.24	151.01
Pork	9.14	1.01
Poultry	2.27	6.49

Source(s): AGMEMOD and CAPRI.

3.4.3 Consumption per capita

The results presented in Table 12 are a reflection of the assumed increase on the share of EU population that will become vegan and vegetarian in the coming years and the expansion of flexitarian diets among the EU citizens. These results confirm the substitution between red and white meat that can be expected in view of the larger negative health impacts of the former (Springmann et al., 2018). As expected both CAPRI and AGMEMOD indicate quite similar declines.

Table 12. Consumption per capita EU28 (% deviation from baseline in 2030) – Scenario 2

	AGEMOD	CAPRI
Beef	-8.95	-8.32
Pork	-8.57	-8.75
Poultry	-0.29	-0.90

Source(s): AGMEMOD and CAPRI.

[9] In general, the product supply part in CAPRI is more flexible to generate quick policy responses to changes in price signals than AGMEMOD. This is due to a difference in modelling approaches, where CAPRI has an explicit (regional) land allocation optimization routine underlying its supply behaviour whereas as the AGMEMOD model follows an elasticity driven approach (with these elasticities being econometrically estimated and thus account for past market-response behaviour of farmers and consumers).

3.4.4 Price developments

The description of the logic behind Scenario 2 (Section 1.3) pointed out a decline in prices that has been confirmed by both models. The results reveal that due to inelastic supply the negative price effect dominates the volume (reduction) effect. In the context of the AGMEMOD simulation, the largest price decline (around -21%) has been identified in the case of pork meat, while CAPRI suggests a smaller decline of around 6 percent. In the case of beef prices, the CAPRI simulation indicates a price decline of about 12 percent, being less than 2 percent the price decline estimated by AGMEMOD. Much smaller declines have been estimated by the two models in the case of poultry which is the kind of meat that is expected to become the preferred consumers' choice in the future.

Table 13. Average price EU28 (% deviation from baseline in 2030) – Scenario 2

	AGEMOD	CAPRI
Beef	-1.57	-12.44
Pork	-20.80	-5.64
Poultry	-2.31	-0.99

Source(s): AGMEMOD and CAPRI.

A final remark should be done by considering the impacts on production/consumption, net trade development and price responses all together. Both AGMEMOD and CAPRI indicate that poultry consumption will decrease. Further comparison of the outcomes AGMEMOD versus CAPRI, reveals that the price decrease is larger in AGMEMOD while net trade increase is lower, which can explain why production decreases in the case of poultry according to the CAPRI model, while it increases according to AGMEMOD.

3.4.5 Additional indicators

This chapter also includes an additional set of indicators regarding farm income and cultivated area which are provided by the CAPRI model (Table 14). As in the case of Scenario 1, the focus of this set of indicators is the crop sector. In general terms, the modelling of this scenario indicates relatively small negative effects on income per hectare in the case of the selected crops, which are around nearly -2.5 percent in the case of cereals and pulses. The impacts on cultivated areas are more heterogenous, with an area increase of 2.4 percent in the case of pulses. For the remaining crops, regardless the direction, deviations with respect to the baseline are below 1% in absolute terms.

Table 14. Additional indicators EU28 (% deviation from baseline in 2030) – Scenario 2

	INCOME PER HA	AREA
Utilised agricultural area	-4.86	-0.17
Cereals	-2.28	-0.58
Oilseeds	-0.61	0.04
Pulses	-2.39	2.41
Potatoes	-0.61	-0.13
Sugar beet	-1.86	0.83
Vegetables and permanent crops	-0.26	-0.11

Source(s): CAPRI.

A more detailed regionalization of the impacts on income per hectare is presented in Figure 13. As in the case of Scenario 1, there is a lot of heterogeneity in the EU with respect to agricultural production at both MS and regional level. Nevertheless, the regions experiencing the most positive impacts seem to be concentrated around the Mediterranean basin.

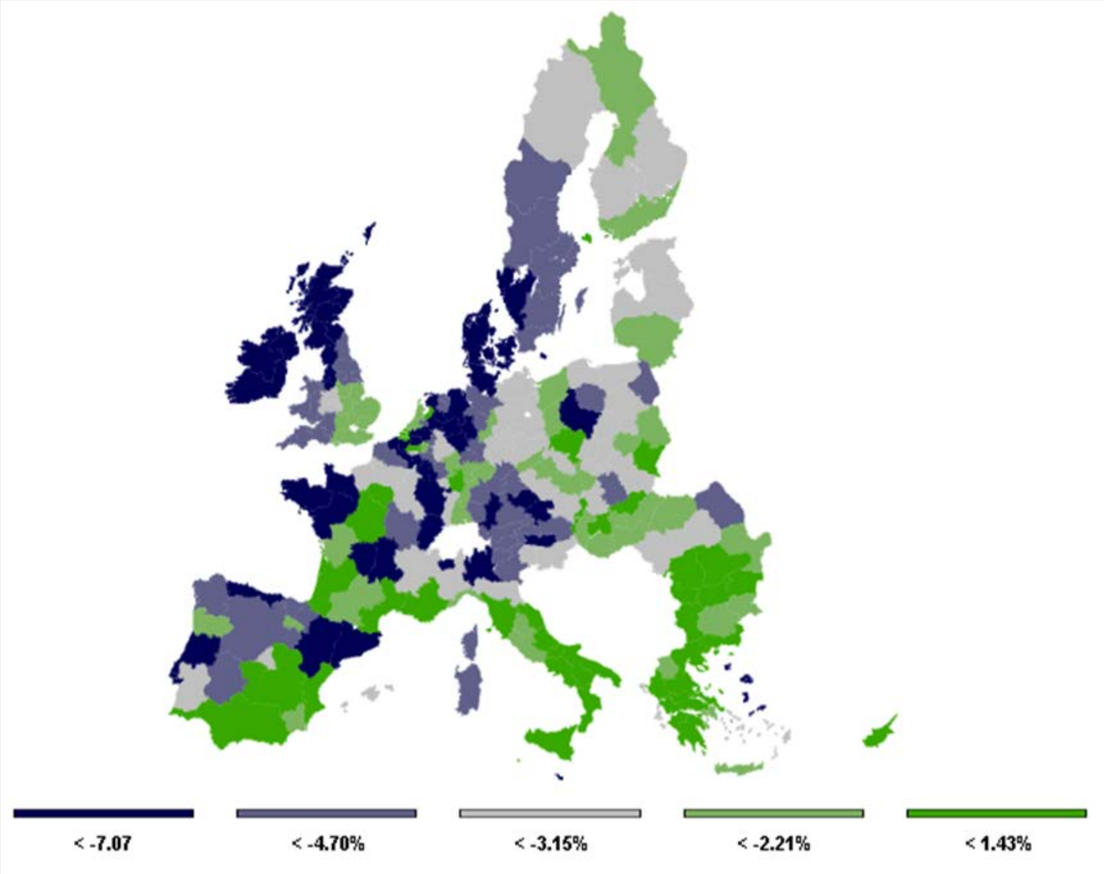

Figure 13. Income per hectare (% change from baseline 2030) – Scenario 2

Source(s): CAPRI.

3.4.6 Environmental impacts

Similarly as it was presented in Section 2.3.6, some environmental indicators are reported to provide insights on the impacts of a meat preference shift that go beyond traditional economic indicators such as production and net trade. As in the case of Scenario 1, the comparison of the outcomes that are delivered by AGMEMOD-MITERRA and CAPRI indicate changes in the same direction although there are differences with respect to the magnitude. In both cases, a decrease in emissions coming from the decline of the activity of the livestock sector is calculated. However, in the system AGMEMOD-MITERRA the main reduction in emission emanates from the decrease in pig numbers. In the case of CAPRI, there is also an additional decrease in the number of cattle heads which is translated into further lower GHG emissions.

Table 15. Emissions EU28 (% deviation from baseline in 2030) – Scenario 2

	MITERRA-Europe	CAPRI
CH_4 emissions	-0.70	-2.01
N_2O emissions	-0.27	-1.31
GHG emissions	-0.47	-1.70
NH_3 emissions	-1.18	-2.07
N leaching	-0.31	-1.65

Source(s): MITERRA-Europe and CAPRI.

Figure 14 presents a map reporting on the changes in GHG emissions that gives an illustration of the potential biophysical impacts at regional level. As in the case of the analysis of the income per hectare (Figure 13) in some cases there is some degree of heterogeneity within countries, e.g. differences in emission reductions between the North-East and the South-West of France. Broadly speaking the transition of the average EU diet towards more sustainable pattern will lead to emissions reductions in more than half of the European territory (green coloured areas).

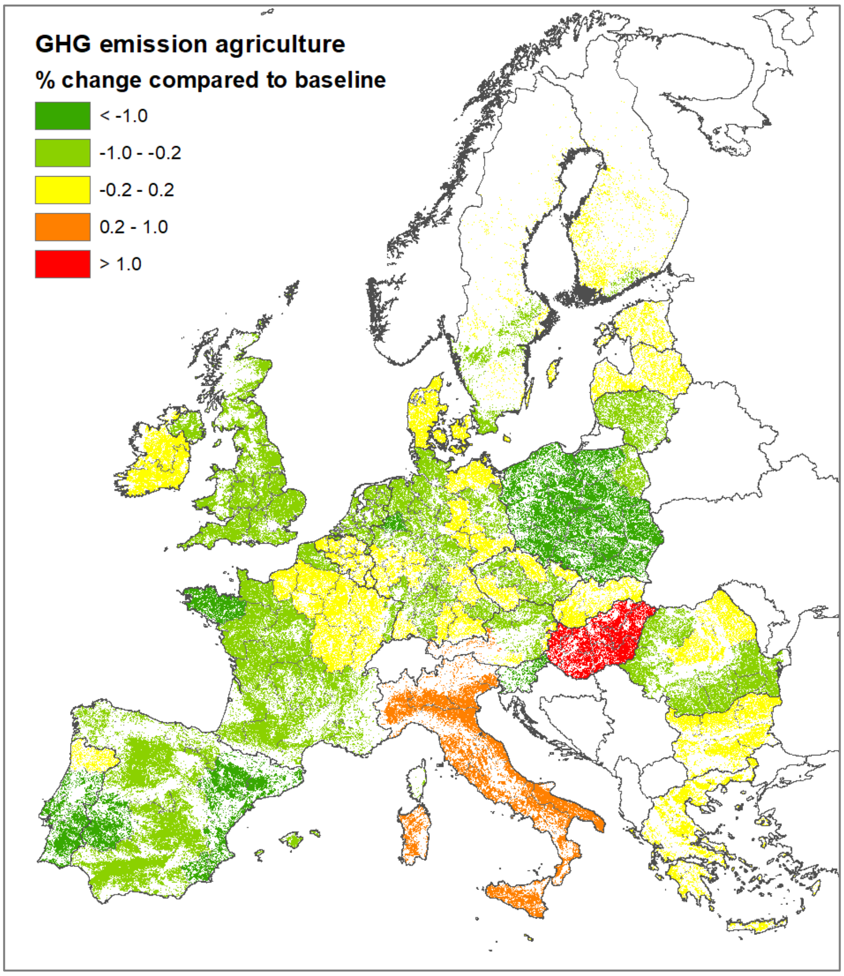

Figure 14. GHG emission agriculture (% change compared to baseline) – Scenario 2
Source(s): MITERRA-Europe.

4 Conclusions

4.1 Introduction

The main purpose of this report is to present results of the medium-term CAP related scenarios that have been done as part of the SUPREMA project. The main aim of this exercise is to compare different models and/or model combinations that have a large degree of 'similarity' as they have a considerable set of joined indicator/variables. As it here concerns a comparison of the AGMEMOD-MITERRA (combined) modelling tool on the one hand and the CAPRI model on the other hand, the main focus has been on comparing and discussing selected model results in both the economic and agronomic or biophysical domains.

Two scenarios have been simulated and compared: (i) a CAP greening scenario; and (ii) a sustainable diet scenario. Both scenarios are hypothetical but have been chosen in such a way that the can provide insights in future policy issues as: (i) a further greening of the CAP fits in the policy implementation space as it is included in the ongoing policy reform of the CAP after 2020; and (ii) as increasing consumer awareness about healthy diets and their relation to meat consumption, as well as the footprint/climate consequences are highly relevant with respect to the Green Deal roadmap (December 2019) and the Farm to Fork Strategy (May 2020) documents that have been recently published.

In the remainder of this chapter, some main conclusions from the comparative assessment will be drawn, which will be decomposed into insights derived from the model comparison of results and some lessons from the analysed scenarios.

4.2 Conclusions with respect to the comparative assessment of model outcomes

As regards the comparative model-results assessment the following conclusions could be drawn:

- The AGMEMOD-MITERRA linkage has been successfully established and is able to present results in a wide economic, biophysical and environmental domain. As such in the AGMEMOD-MITERRA model combination and CAPRI model have the quality to be able to address a wide set of similar policy questions.
- Both the AGMEMOD-MITERA and CAPRI models are partly relying on different approaches and philosophies. The AGMEMOD model contains a lot of econometrically estimated behavioural equations at sectoral or Member State level, whereas CAPRI relies more on a 'representative regional farm' approach (calibrated to a base year), where the optimal land use and agricultural activity mix follows from solving a profit optimization problem. This easily goes with different responses to prices and price changes, whereas it was observed that demand and supply in AGMEMOD are in general less price and income responsive than in CAPRI. This explains part of the found differences in model outcomes.
- Both compared models satisfied the general properties from economic theory one would expect these models to follow.
- Part of the observed differences in the outcomes could be traced back to the way the simulated policy measures have been implemented. The models often present policy measures in a 'stylized' way, whereas in reality the implementation modalities of similar measures can be complex and differ over Member States.
- Both AGMEMOD and CAPRI have differences with respect to the way price transmission is modelled and functioning. In AGMEMOD, for example, in several instances the self-sufficiency rate at EU (key price) as well as at Member State level plays a role. With the increase in the market orientation of the CAP since the last decades the implications of this for the price transmission may not always fully reflect current market conditions (several of these price transmission equations have been re-estimated and updated, but not all). In CAPRI, price transmission equations link prices along the value chain and bilateral trade flows are using (Armington assumption).
- CAPRI models the current CAP in great detail, representing the implementation of CAP measures at MS and NUTS-2 levels (direct payments, greening conditions, etc.).

4.3 Concluding remarks with respect to the analysed scenarios

A number of insights can be gained from the simulated scenarios, which are seen as useful for both policy makers as well as modellers:

- It is good to note, that from the CAP scenario it turns out, at least indirectly, that there is evidence about the decoupling of payments. As regards AGMEMOD this has an empirical bases as many of its behavioural equations have been econometrically estimated using historical data.
- There is a trade-off in both models with respect to greening and agricultural production, which is also in line with basic expectations from economic theory. However, as the CAP simulation results show, for the range of 'policy shocks' that were simulated this trade-off was limited. This suggest that a simultaneous realisation of farm income (as related to agricultural production) and sustainability objectives could be feasible already at low costs or compensations.
- Emissions are coupled to production; this holds for both models. New policies aim to decouple emissions from production (e.g. EU Green Deal and Farm to Fork Strategy). This underscores the importance of having a detailed and refined policy representation of climate measures and land management practices in place in models that are used for the impact assessment of such policy measures.
- The results of the CAP scenario emphasize the importance of pursuing environmental, biodiversity and climate policies in a targeted way. EU agriculture is characterized by quite some heterogeneity both at Member State level as well as within Member States at regional level. This creates challenges for both policy makers as well as modellers to account for a proper level of 'spatial disaggregation' when implementing policies and assessing their impacts. The CAP scenario showed that substitution and spill-over effects can at regional level create 'differences in direction' of policy impacts.
- The analysed CAP scenario is a rather stylized one. The most important reason for this was the lack of information about the National Strategic Plans and the intended policy implementation by Member States under the new CAP. But even when such information would have been available it might not have been easy for the used models 'to explain' the adoption of, for example, new eco-schemes. For both models additional efforts would be required to include this in a reliable way. As such this provides an illustration that changing policies require also that models are changed and updated with respect to these policy changes (maintenance).
- From the healthy diets-scenario simulation it was found that there are two aspects that need careful handling and examination. First, the increase in market orientation of the CAP has contributed to a certain extent of 'disconnection' of producer and consumer prices. Changes in consumer behaviour will for that reason not lead to fully parallel changes in producer behaviour. For policy makers pursuing climate policies this could be a reason to have a careful look at leakage-effects (due to stronger adjustments in trade rather than in production). Second, consumers and producers are still 'connected' because the EU's competitiveness may be limited for specific products. Already small changes in consumption may create challenges with respect to the competition for the concerned sectors, as it can increase the reliance on world markets of EU agriculture for product disposal.

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Appendix: Literature review

A Studies on sustainability of EU agriculture

Table 1 provides a short overview of studies that made simulations to assess how a more sustainable EU agriculture could be achieved. The EU's CAP proposals-impact assessment is probably the most relevant study, but it only could provide a rather rough analysis as the uncertainties then were even larger than at the current moment.

Table 16. Overview of scenario assumptions to model the effects of improving the sustainability of EU agriculture from selected studies in period 2010-2019

REFERENCE	SCOPE	ASSUMPTIONS MODELLED IN ALTERNATIVE/COMBINED SCENARIOS
Domínguez et al. (2012)	Agricultural GHG emissions in the EU; an explorative assessment	• Explores a large set of technical measures • Has a weak representation of the CAP as a supportive policy to climate change
Van Doorselaer et al. (2015)	Economic assessment of GHG mitigation policy options for EU agriculture	• Uses different assumptions on the availability and uptake of technological mitigation options • In scenarios values for GHG emission caps were set (at MS and NUTS2 level), requiring reductions of agricultural GHG emissions of 19% or 28% respectively by 2030 compared to the year 2005. • Scenarios include option for (non) trading of emission permits. • Alternative scenarios were tested in which no mandatory targets are in place but subsidies for the voluntary uptake of the technological mitigation measures are introduced.
EU commission (2018)	Impact assessment of the cap beyond 2020 proposals	• Allocate budgetary resources within pillar 1 of the cap from direct income support to a direct greenhouse gas (GHG) reduction subsidy for EU farmers
Himics et al. (2018)	Climate action as the priority for the cap	• Allocate budgetary resources within pillar 1 of the cap from direct income support to a direct greenhouse gas (GHG) reduction subsidy for EU farmers • Optional technological GHG mitigation options for EU farmers
Lesschen et al. (2020)	Scenarios for Dutch agriculture addressing environmental and climate challenges	• Includes several scenarios for 2050 (large and restrictive environmental operating space, extensive and high-tech agriculture, allowance of carbon sinks (forestry, biomass production) and has a detailed set of technical measures.

Source: Authors.

Note(s): Except for Lesschen et al. (2020) all other mentioned studies involved the CAPRI model, which is an 'advanced player' in the field and has been adjusted to address climate issues during the ECAMPA-projects. For the technological GHG mitigation options, often the GAINS database was used, as it already provides mitigation technologies and their cost structure. Only technologies have been considered which are assumed to be commercially available before 2030. Lesschen et al. (forthcoming) also considers technologies that could become available after 2030 but before 2050. A recently published study by Alliance Environment (2019/EU Commission, will be added later to this table).

B Studies on meat consumption

Despite the uncertainty regarding the development of consumer preferences, there is a strong consensus about the expectation of rising world demand for meat in the coming years. For example, Accenture (2017) projects that global protein demand could increase by 80 percent over today's levels by 2050. Along the same lines, Ritchie et al. (2018) project global meat consumption to increase by 75–80% by 2050, as a reflection of population and economic growth. Gokirmakli and Bayram (2017) also indicate a strong increase in meat consumption over the period 2000-2030 (around 72%).[10] However, CB Insights (2019) reports that plant-based protein is growing almost a little faster than animal-based protein, assuming this trend for the coming years.

Drawing attention to environmental impacts, Kim et al. (2015) highlight the mitigation potential of reducing meat consumption, which could reduce emissions from the agricultural sector by 55-72% and even more if consumption of dairy and eggs is also reduced. More specifically, a global reduction in meat and dairy intake by 75 percent by 2050 could reduce emissions by 7.4 Gt. [11]

Table 17. Overview of scenario assumptions to model the effects of dietary changes on emissions

REFERENCE	SCOPE	ASSUMPTIONS MODELLED IN ALTERNATIVE/COMBINED SCENARIOS
Bajželj et al. (2014)	Agriculture and land use change are included	• Meat intake increases with GDP • Increased agricultural yields • 50% reduction in food waste • Healthy diet
Tilman and Clark (2014)	Agricultural land use change is excluded	• Meat intake increases with GDP • 15% less meat and fish • No meat or fish
Popp et al. (2010)	Scenario for 2055; non - CO_2 emissions only	• Meat intake increases with GDP • Meat intake declines by 25% every 10 years • Meat intake declines + technology mitigation
Stehfest et al. (2009)	Land - use emissions only	• Meat intake increases with GDP • 15% less meat • No meat • No meat, eggs, or dairy
Hedenus et al. (2014)	Excludes agricultural land use change	• Meat intake increases with GDP • 15% less meat† • 75% less meat and dairy

[10] FAO indicates that meat consumption per person in 2030 could be around 100kg/per person/per year in the case of developed economies. See, also, Gokirmakli and Bayram (2017).
[11] This figure is comparable to the emissions of the transportation sector in 2010 (7.0 Gt).

Westhoek et al. (2014)	Livestock production, feed use, land use and N flows are considered	• Replacing 25-50% of animal-derived foods with plant-based foods on a dietary energy basis

Source: Adapted from Kim et al. (2015).
Note(s): Kim et al. (2015) define 'healthy diet' as the one 'that limits intake of red meat (max of two 85 g / 3 oz. portions per week), poultry (max of one 85 g / 3 oz. portion per day), dairy, eggs, sugars, and oils to levels recommended by health organizations (e.g., WHO, FAO, American Heart Association, Harvard Medical School), and sets a minimum for fruit and vegetable intake'. The modelling exercise undertaken for Westhoek et al. (2014) also involved the use of the MITERRA model.

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