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Supplementary Materials for

A greener path for the EU Common Agricultural Policy

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SM8 Raw outcomes of SDG evaluation of relevance and performance (Excel)

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1. Supplementary Material 1: Methods

1.1 Relevant Fitness Check methods

Much of the knowledge base used in the paper builds on a literature review published by (*16*). Overall, the study followed the Fitness Check methodology outlined by the European Commission (EC) in the REFIT program (*17*). EC guidelines for policy analysis prescribe five key assessment topics: whether a policy is ***effective*** in fulfilling its objectives, ***efficient*** in terms of costs being proportional to benefits, ***coherent*** internally among its instruments and externally with other policies, ***relevant*** in addressing current challenges, and ***EU added value*** beyond what national or subnational policies can offer. Moreover, (16) addressed the question to which extent the CAP can deliver on the UN's SDGs.

Topics covered in the Fitness Check were chosen based on the intersection between CAP objectives, Fitness Check criteria, and relevance to SDGs. Environmental themes included 1) Climate action and energy, 2) Soil and water protection, 3) Biodiversity and ecosystem services, 4) Organic farming in the context of sustainable farming, and 5) Animal welfare. Socio-economic aspects were 6) Farm productivity and efficiency, 7) Fair standard of living for farmers, 8) Market stability, and 9) Balanced territorial development. In addition to these, overarching topics, which emerged partly from societal discussions and SDGs, were 10) Health, sustainable consumption and production, 11) Reduced inequalities, and 12) Global-scale effects of the CAP.

Literature search covered both environmental and socio-economic aspects, to achieve a balanced knowledge base regarding the topic and geography, focusing on publications linking the CAP instruments with impacts. The literature gathered (~900 publications) integrates mainly English, peer-reviewed scientific literature from 2006-2017 (73%), but also various reports (national/EU/EC) and data (e.g. Eurostat, FAOSTAT). The resulting database (*16*) was updated during the process of preparing this publication and served as the empirical basis we used to support our arguments.

We note that, as a baseline or **counterfactual to evaluate the CAP**, authors of the original studies used a range of approaches including 1) responses to policy changes in the CAP; 2) "hypothetical scenario" asking what would happen in the absence of the CAP (based on modelling, surveys, simulations); 3) assessing developments in new accession countries entering the EU (especially in 2004 and 2007); 4) comparing countries within versus outside the EU (while considering the heterogeneity in socio-economic and political contexts); 5) a "control-impact" approach assessing heterogeneity between MSs with respect to how MSs interpret and implement the CAP, or more locally, 6) by comparing the outcomes for farms that follow, or do not follow, a given CAP instrument. These were used to gain trust that the published studies indeed addressed the CAP performance, rather than trends and processes that may result from various factors beyond the CAP.

The Fitness Check document including detailed methods and outcomes is available at www.idiv.de/cap-fitness-check.

1.2 Evaluation of CAP relevance, performance and potential for SDGs

The European Commission identified the CAP as potentially contributing to thirteen SDGs (*6*), although it did not quantify the relevance and potential of the policy to contribute to each of these. To define which SDGs could be CAP-relevant we examined the 162 targets pertaining to all SDGs, and ranked the potential relevance of European agriculture and the CAP for each of these, using a Likert scale: 1=low or none, 2=moderate, 3=high and 4=very high. The analysis was performed both by authors of this publication and by experts with high familiarity of the CAP, selected using a snowball approach while trying to achieve a balanced representation of scientific fields. We obtained 24 replies, with a balanced representation between ecologists (n=10) and experts from economy, social and political sciences (n=14). Some answers with mixed replies (e.g. 1-2) were replaced by their average value (1.5). We estimated median ranks for each target and averaged across all SDGs' respective targets. The potential relevance of the CAP to each SDG was then classified as low, moderate, high and very high based on the distribution of the 25, 50 and 75 % percentiles of these averages. We used standard deviations as a measure of uncertainty. We note a high correlation between ecologists and socio-economists' ranking (0.95), gaining confidence that the assessment of relevance is robust to ones' scientific field.

Next, we assessed the performance of the current CAP regarding SDGs, based on the Fitness Check assessment *(7)* which included a workshop to evaluate, discuss and re-evaluate the CAP's performance based on a Delphi process. Considering that SDGs were adopted in 2015 and the EC outlined its commitment to address them in 2016 (*18*), there is limited literature available to assess CAP's potential contribution to all relevant aspects sustainability. Nonetheless, authors of the fitness check (7) used an indirect approach which links published results to the topics integrated within each SDG, and thereby, assigned a level of SDG support for the current CAP (substantial; some; limited; little or no support). Confidence levels were assigned based on the extent and consistency of the literature, i.e., whether studies show a consistent positive or negative effect, or indicating contrasting or mixed effects.

We updated the results of the fitness-check evaluation to extend it to the CAP post-2020 proposal based on current performance as well as the prevalence and budget of existing instruments, leading to a slightly different categorization and ranking of two SDGs.

All assessments and justifications can be found in Supplementary Material 8 (science.sciencemag.org/content/365/6452/449/suppl/DC1)

Finally, we identified potential improvements for the proposed CAP (compared to the current legislation) based on relevant literature, focusing especially on SDGs to which the CAP's potential relevance is moderate to very high. We considered four categories of improvements: improving existing instruments; creating missing instrument; improving coherence within the CAP and with other policies; and addressing impacts outside the EU

1.3 Evaluation of the proposed CAP and the reform process, development of recommendations

We have followed the policy process to identify a) whether and how the proposed CAP addresses key weaknesses as identified in the literature, and b) whether the process was responsive to evidence in general and to public demands in particular. Key documents consulted for the evaluation included:

a. **The Future of Food and Farming (*6*):** The EC outlined the upcoming CAP proposal and opened it to comments and responses. Authors of the fitness check evaluated this document against the Fitness Check and submitted comments to the Commission in January 2018. The ten points submitted were re-examined within publications of the CAP proposal.

b. **Multiannual Financial Framework (MFF)** released May 2018, and **CAP proposal** released in June 2018, were scanned systematically, and assessed for the following points:

   i. Impact Assessment and introduction within the proposed CAP: how does the Commission justified the proposal?

   ii. Objectives (Articles 5-6): are they coherent, clear and justifiable? How easy are they to convert into measurable targets and indicators?

   iii. Evolution of Direct Payments (both decoupled and coupled), as well as the redistribution mechanism (Article 15): do they address published critic?

   iv. All elements of the Green Architecture, including Agri-Environment-Climate Measures (AECM), Cross-Compliance (Annex X), Eco-schemes (Article 29), and related articles (Articles 90, 92). Here we asked whether key issues in the literature were addressed.

   v. All instruments that can be unsustainable or potentially serving as incentives for intensification, particularly sectoral payments, payments for young farmers, Areas of Nature Constraints (ANC), etc.: here we asked whether any sustainability considerations have been made or included. We assumed that absence of reference to environmental criteria can be considered as lack of such a requirement.

   vi. Indicators and monitoring (Articles 94, 111, Annex I). Here we examined whether the indicators are clear, relate clearly and consistent with the objectives, whether Result indicators can serve as proxies for potential impacts, and are accordingly coherent with Impact indicators. We further examined whether indicators are S.M.A.R.T (Specific, Measurable, Achievable, Relevant and Time-bound).

c. **Independent Evaluations of the CAP** or elements of it published after its release, such as:

   i. The response of the EU Court of Auditors to the EU white paper “Future of Food and Farming of November 29, 2017 (*19*)

ii. The statement of the Scientific Council for Agricultural Policy at the ministry of Food and Agriculture (BMEL) in Germany, commenting on the principles for a new CAP-reform (*11*).
iii. Various blog-posts of Alan Matthews, as well as Emil Erjavec, on the status, process and contents of the CAP-reform on www.capreform.eu (*20-22*).
iv. Scientific publications on the CAP-reform post 2020 (for example (*8, 23*).
v. Other non-referenced publications by scientists (e.g. (*13, 24*), GOs and NGOs).

Our assessment of the CAP and reform process, as well as development of the recommendations, were supported by three workshops conducted in Leipzig (October 2017 and December 2018) and Berlin (November 2018). The two latter workshops included a range of attendees including scientists, policy makers, administrators, consultants and other key stakeholders (Environmental NGOs, farmer organizations). Regarding SDGs, information beyond the Fitness Check was complemented by the EU's Sustainable development report (*1*). Evaluation of the proposed CAP as presented in this paper is based on a thematic orientation, taking a logical line starting with formulation of objectives, through the set of instruments and budgets to enable implementation, to the actual implementation model and its evaluation. We additionally evaluated the reform process itself, considering the various factors and actors that shape the reform path itself. SDGs are considered as a cross-cutting theme in our evaluation but placed as objectives under the assumption that this is where streamlining of the policy should take place.

2. Supplementary Material 2: Align CAP with SDGS

Statement: Three new objectives that address environmental and societal challenges were introduced in 2010, but the overall set of objectives remains incoherent and unbalanced

Having two diverging sets of CAP-objectives – one formulated in the Treaty of Rome 1957 and constitutionalized again in the Treaty of Lisbon 2009 (TFEU) (*12*), the other one serving as introductory part of the legal text in the reform-regulation of 2013 and 2018 (*2, 25*) – creates confusion and hampers effectiveness and efficiency (*16*). The former (5 objectives) are by now largely outdated, poorly reflect current European challenges (*16*), and some have already been fulfilled or even over-fulfilled. For instance, ensuring food security in a (post-war) Europe (Objective a) has already been addressed and even resulted in overproduction in the 1980s and is therefore not a relevant objective (*1, 26-28*). Moreover, rather than stimulating higher agricultural production in Europe, the current challenge is to balance productivity with other objectives (*29*). Similarly, availability of supplies (objective d) is an outdated challenge in most MSs (for example (*26, 29-31*)). Moreover, uneven distribution of direct payments among farm classes as well as among MSs suggests that the CAP in general and DP in particular have failed to reduce disparities and achieve a fair standard of living (objective c), and is inefficient in meeting farmer needs (for example (*28, 32*)). Conversely, environmental issues, rural vitality and inequalities among parts of the EU regions are not listed in the original objectives.

Acknowledging the limited relevance of these objectives to current challenges, in 2010 the EC presented a new set of priorities (i.e. new objectives) that are also reflected in the 2013-reform (*25*), and maintained and expanded in the proposed CAP beyond 2020 (*2*). However, the old objectives and new priorities overlap, while some terminologies are still inconsistent or confusing (such as productivity versus production) and specifications are often missing. Maintaining both sets of objectives creates confusion regarding how the EU and MSs treat the various forms of objectives (Table S2.1 and Figure S2.1).

Table S2.1: Three systems of objectives for the CAP 1957-2018.

CAP-Objectives of 1957/2009 in the TFEU *((12),* Art. 39, *own highlighting)*	**Current CAP-Objectives of the CAP 2013-2020** *(33)*	**CAP-Objectives post-2020** *(6),(2), Art. 5/6; own highlighting)*
Productivity *a) to increase* ***agricultural productivity*** *by promoting technical progress and ensuring the rational development of agricultural production and the optimum utilisation of the factors of production, in particular labour;*	**Objective 1: Viable food production** 1a) contribute to **farm incomes** 1b) improve the **competitiveness** of the agricultural sector and to enhance its **value share in the food chain** 1c) compensate for production difficulties in areas with specific **natural constraints**	**A) to foster a smart, resilient and diversified agricultural sector ensuring food security** (a) **support viable farm income** and resilience across the Union to enhance food security; (b) **enhance market orientation** and increase **competitiveness**, including greater focus on research, technology and digitalisation; c) improve the farmers' **position in the value chain**;
Fair Standard of Living *b) thus to ensure a* ***fair standard of living*** *for the agricultural community, Increasing the* ***individual earnings*** *of persons engaged in agriculture;*	**Objective 2: Sustainable management of natural resources and climate action** 2a) enhanced provision of environmental **public goods** 2b) to foster **green growth** through innovation 2c) pursue **climate change** mitigation and adaptation actions	**B) to bolster environmental care and climate action and to contribute to the environmental- and climate-related objectives of the Union;** (d) **contribute to climate change** mitigation and adaptation, as well as sustainable energy; (e) foster sustainable development and **efficient management of natural resources** such as water, soil and air; (f) contribute to the protection of **biodiversity,** enhance ecosystem services and preserve habitats and **landscapes**;
Market Stability *c) to* ***stabilise markets;*** *d) to assure the* ***availability of supplies;*** *e) to ensure that supplies reach consumers at* ***reasonable prices****.*	**Objective 3: Balanced territorial development** 3a) to support **rural employment** and maintaining the social fabric of rural areas *3b)* improve the rural economy and promote **diversification** *3c)* to allow for **structural diversity** in the farming systems, improve the conditions for small farms and develop local markets	**C) to strengthen the socio-economic fabric of rural areas** (g) **attract young farmers** and facilitate business development in rural areas; (h) **promote employment, growth, social inclusion** and local development in rural areas, including bio-economy and sustainable forestry; (i) improve the response of EU agriculture to **societal demands** on food and health, including safe, nutritious and sustainable food, food waste, as well as animal welfare.

Source: (*12*), Art. 39, (*33*) and (*6*).
Note: To facilitate a comparison between objectives, we added the category-definitions "productivity", "income" and "market stability" to the objectives of 1957 (TFEU (5), article 39). The objectives c, d and e were summarized under market stability.

In addition to the CAP-objective, other fundamental objectives of the TFEU must be taken into account in its design:

Environmental targets (Article 11, TFEU): “environmental protection requirements must be integrated into the definition and implementation of the Union’s policies and activities, in particular with a view to promoting sustainable development” (*12*). As a binding provision in the general Part 1 on of the principles of the TFEU, Article 11 must be fully observed in the CAP. This entails the CAP must also serve to protect the environment and shall not counteract it, meaning also that the SDGs should be regarded as relevant guidelines for policy formulation. This environmental dimension is missing in the constitutionalized CAP-objectives (article 39, TFEU).

Social market economy (Article 3(3), TFEU): “The Union shall establish an internal market. It shall work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment. It shall promote scientific and technological advance.” This norm suggests that EU policies should aim to balance between economic growth, social inclusion and participation, also within the CAP.

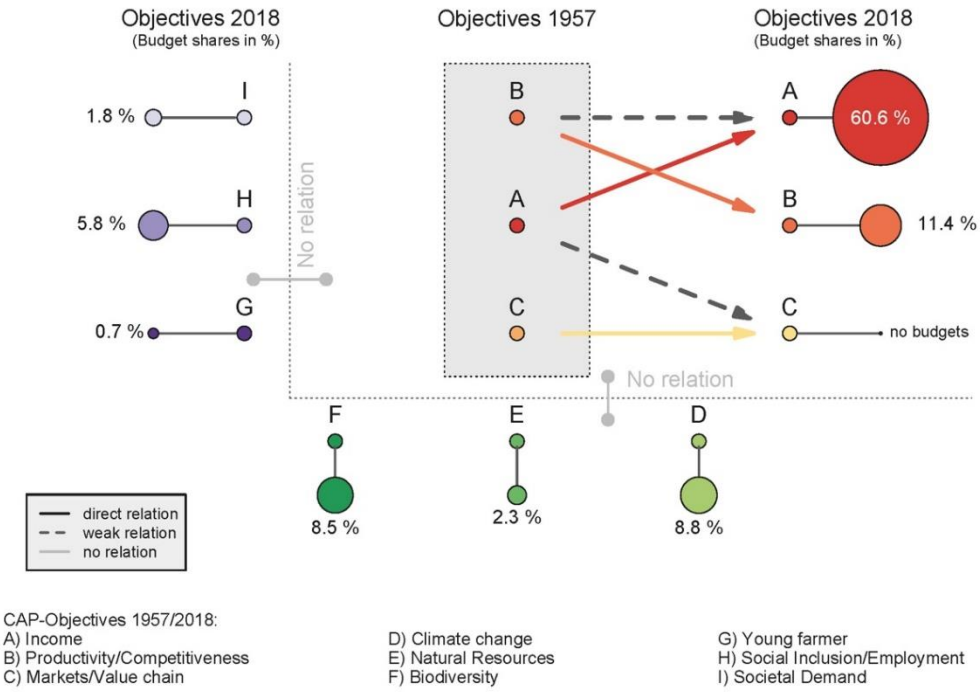


Figure S2.1: Relation between the new proposed set of objectives (*2*) and the established CAP-objectives, stemming from the Treaty of Rome of 1957 (TFEU), and constitutionalized in the Treaty of Lisbon 2009. A) objective texts (article 6), B) budget shares based on current instruments and budgets. For values feeding into Fig. S2.1 please see Table S2.3.

Statement: We estimate that the CAP can make a substantial contribution to nine SDGs, yet its current instruments provide some support only to SDGs 2 (zero hunger) and 1 (no poverty), and limited to no support to all other SDGs

Sustainability is repeatedly highlighted in the literature as a key challenge in the agricultural sector, from both the socio-economic and environmental perspectives (e.g., (*34-37*)). The EC identified CAP as relevant for addressing thirteen SDGs.

According to expert evaluations of the targets associated with all 17 SDGs (for Methods see SM 1.2), the CAP has high to very high relevance to attaining nine SDGs, namely 1, 2, 6, 8, 11, 12, 13, 15 and 17 (Table S2.2; First figure in the main text). Our assessment on SDG-targets indicates a slight deviation from the list proposed by EC, with SDG 10 (not listed by the Commission) being somewhat relevant, whereas for SDG 4, listed by EC as relevant, we could not identify any target that the CAP could contribute to. We note that (*38*) identified 47 targets of high relevance for the CAP, covering almost all SDG (except SDGs 16 and 17).

Our assessment further indicates that, in its current design and implementation, CAP has been quite limited in its support for most SDGs. Specifically, **only for two SDGs there is reasonable CAP support** (First figure in the main text)**:**

- **SDG 2** (Zero hunger) and **SDG 1** (No poverty) are somewhat supported through both DPs and RDP payments. CAP contributes to farm economy, yet the inefficiencies that result from unequal distribution of payments, and strong leakages from farmers, weaken its potential to both objectives. The contribution to SDG 2 is somewhat mixed, since farm productivity has increased (especially following the Fischler-reform of 2003) but a meta-study of 195 field studies shows negative effects of DP on technical efficiency and, thereby, productivity (*39*). We note also that food security or extreme poverty are not key challenges in the EU (*28, 40, 41*), with EU's impact on other regions, for example,. developing countries conflicting SDGs 1 and 2 at the global level (*42*).

Four SDGs have limited CAP support:

- **SDG 6** (Clean water and sanitation) and **SDG 15** (Life on land) are partly supported by designated instruments showing some local successes, yet limited budget and inefficient implementation do not scale up to halt the overall negative trends of environmental degradation. While the longer-term impacts of Greening have not yet been evaluated, its design and implementation (for example, marginal number of farmers changing land-use) strongly indicates that it is unlikely to reverse the trends. Therefore, CAP's potential contribution to meeting SDGs 6 and 15 is not sufficient (e.g. (*16, 43-47*)). We note, however, that adverse effects on Nitrate levels in groundwater have recently improved (*41*).

- **SDG 8** (Decent work & economic growth) relates to several topics addressed by the CAP such as promotion of green growth, generational renewal and (un)employment among youth, as well as rural vitality in general. Our results indicate that CAP supports some forms of sustainable farming, for example by supporting the expansion of the organic farming sector, thus contributing to a green growth strategy (*48-53*). However, while CAP also supports unsustainable farming systems, agricultural employment continues to decline, and therefore CAPs potential contribution to SDG 8 is rather limited (*16*).
- **SDG 10** (Reduced inequalities) implies that farmers with the lowest incomes should benefit most from CAP payments. Although CAP includes supports aiming to a more balanced territorial development, areas under nature constraints and young farmers, 80% of DP go to ~20% of beneficiaries (*54*), and levels of inequity in payment distributions increased in some new MSs over the past few years (*41*). Altogether, numbers highlight a limited capacity of the CAP to address inequities in the farming sector and hence support SDG 10. Further, mechanisms installed in the 2013 reform for capping and redistribution have not been effective, and those proposed in the new CAP appear stricter.

Three SGD were identified as having little or no CAP support:

- **SDG 13** (Climate action) is insufficiently addressed due to the lack of instruments targeting the main sources of GHG emissions, even if some AECM and EFA options support climate-change mitigation. Furthermore, the inclusion of climate within AECM, yet with a reduced budget, as well as competition between AECM and Greening, has likely weakened the CAP's capacity to address climate change. Overall, increasing agricultural GHG emissions in recent years clearly indicate CAPs limited contribution to SDG 13 under its current design (*28, 55-64*).
- **SDG 12** (Responsible consumption and production) as well as **SDGs 3** (Good health and wellbeing) have insufficient support, although they are partially addressed by regulations on agro-chemicals (some of which external to CAP, such as the Nitrates and Water-Framework Directives). Instruments supporting biodiversity and ecosystem services (particularly AECM) also contribute indirectly to well-being by maintaining public goods such as aesthetic landscapes, but their extent of impact is limited. Healthy diets are promoted by school schemes but the extent of these schemes is exceptionally limited. The wellbeing of farmers is only considered from an economic perspective, and not addressed in its broader sense by relevant indicators. CAP is not well-designed to address the challenges of unhealthy diets, obesity, and health issues relating to these. Its indirect contribution to consumption behavior by offering, for example, an over-proportional share of coupled payments to dairy and meat products (51% of coupled payments (*65*)), conflicts with SDG 12. Note however, that part of SDG 3 and 12 are influenced by issues related to consumer policy, and thus less relevant for agricultural policy. Addressing SDG 3 and 12 is subject of a policy package of a different policy sector.

Remaining SDGs were not assessed in the fitness check due to lack of information/evidence.

Table S2.2: CAPs potential relevance for each of the SDG targets.

For each SDG, potential relevance reflects the average of median values obtained from all surveys, for all SDG targets. Scale values ranged from 1= low/irrelevant; 2= moderate; 3= high; 4= very high. Range for median values across targets within each SDG are shown between brackets and higher values highlighted in bold. See SM 1.2 for detailed methods and SM5 for raw evaluations and calculations.

SDG #	SDG title	Defined as relevant by EC (*7*)	CAP potential relevance
Goal 1.	***End poverty in all its forms everywhere***	**+**	**1.2 (1-4) (high)**
Goal 2.	**End hunger, achieve food security and improved nutrition and promote sustainable agriculture**	**+**	**2.9 (1-4) (very high)**
Goal 3.	*Ensure healthy lives and promote well-being for all at all ages*	+	1.1 (1-4) (low)
Goal 4.	*Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*	+	1.0 (1-3) (low)
Goal 5.	*Achieve gender equality and empower all women and girls*	+	1.1 (1-3) (low)
Goal 6	**Ensure availability and sustainable management of water and sanitation for all**	**+**	**2.2 (1-4) (very high)**
Goal 7	*Ensure access to affordable, reliable, sustainable and modern energy for all*	+	1.2 (1-3) (moderate)
Goal 8	**Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all**	**+**	**1.4 (1-4) (high)**
Goal 9	*Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*	+	1.0 (1-3) (low)
Goal 10	*Reduce inequality within and among countries*		1.2 (1-3) (moderate)
Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable**	**+**	**1.6 (1-4) (high)**
Goal 12	**Ensure sustainable consumption and production patterns**	**+**	**2.3 (1-4) (very high)**
Goal 13	**Take urgent action to combat climate change and its impacts**	**+**	**2.0 (1-4) (very high)**
Goal 14	*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*		1.1 (1-4) (moderate)
Goal 15	**Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss**	**+**	**2.7 (1-4) (very high)**
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels		1.2 (1-4) (moderate)
Goal 17	***Strengthen the means of implementation and revitalize the global partnership for sustainable development***		**1.3 (1-4) (high)**

Statement: Several objectives conflict with each other and with original 1957-objectives

There are conflicts between the three types of objectives, marked as c), d) and e) in Figure S2.2. Besides conflicts between the three dimensions, conflicts objective 1 income and competitiveness, marked as a) and b) can also be observed. Below we elaborate on each of these conflicts.

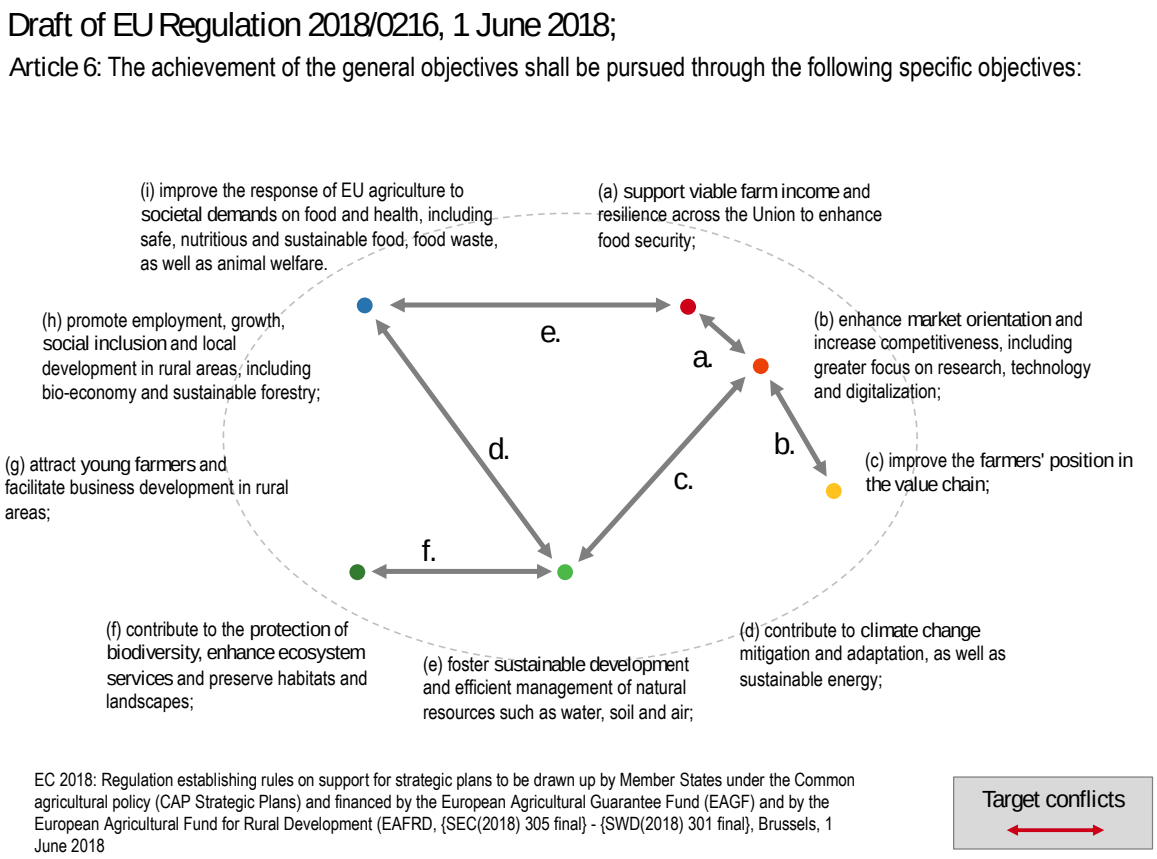


Figure S2.2: Potential conflicts between the CAP post 2021 objectives

Source: own presentation; based on (*2*). **Note:** For simplification, we summarized the Article 5 terms as follows: a) "*to foster a smart, resilient and diversified agricultural sector ensuring food security"* was translated to "***1. Income and competitiveness***", b) "*to bolster environmental care and climate action and to contribute to the environmental- and climate-related objectives of the Union*" was translated to "***2. Environment***" andc) "*to strengthen the socio-economic fabric of rural areas*" was translated to "***3. Rural development***".

a) Income vs. competitiveness

An income support tool like DP might foster less competitive farms in the business, especially if used to overcome liquidity risks or to finance investments on farms. Maintaining less competitive farms can have positive social impacts but can also be seen as an obstacle to farm growth and hence the objective of promoting a competitive EU agriculture.

b) Farmers position in the value chain vs. competitiveness

Improving famers' position in the value chain implies that the EU would control prices within the value chain and intervene in the markets. As objective c) states that the CAP shall enhance market orientation, intervening in value chains without a demonstrated market failure or indicating what type of intervention, may lead to a contradiction. In fact, in the case of a market failure, removing market concentration, for example, *monopsonistic* (i.e. one demander per many suppliers) or *monopolistic* (many demander and one supplier) market structures might help restore functioning markets. The critical issue is primarily that the EC has not provided evidence of market failures.

c) Competitiveness vs. Environment and d) Rural Development vs. Environment

One of the major conflicts within Pillar 2 are farm investment programs and AECMs, both under objective 2 and 3 (Figure S2.2). Farm investments often promote intensification, conflicting with the aim of fostering sustainable farming systems. Investing into intensive animal production, both through Pillar 2 investments and coupled payments, conflict both with climate mitigation and biodiversity-protection targets as it is associated with intensified grassland use and direct and indirect contributions to GHG emissions. Furthermore, supporting renewable energy (stated in "d) Rural development") can conflict with environmental objectives as it supports monocultures, such as maize in crop rotation and high nutrient uptake.

e) Income and competitiveness vs. Rural Development

A competitive farm structure can conflict with the maintenance and development of lively villages, since in some regions, farming will be ceased. The objectives of competitiveness and inclusiveness therefore come in conflict with each other. Additionally, attracting young farmers might contradict the provision of income support, which might still maintain older farmers in the sector. Young farmers are vital for the renewal of the agricultural sector as stated in g) (Table S2.1). It deems difficult for young farmers to further develop their farm business if the largest share of financial resources are still taken by the established farms, receiving support as DP or price support for decades.

f) Efficiency management of natural resources vs. contribution to the protection of biodiversity

Promoting efficiency in using natural resources does not necessarily ensure that resources are preserved or used sustainably. More efficient extraction of resources can lead to depletion and degradation, as well-exemplified in the case of fisheries and demonstrated for agricultural areas in Europe and elsewhere (*66, 67*). Especially by linking efficient use of natural resources to the objective of supporting growth, this objective can lead to undesirable outcomes conflicting objective (f).

Statement: The proposal does not clarify how priorities should be set and trade-offs addressed, especially when budgets are strongly unbalanced

The proposed new objectives may reflect a holistic view on the challenges of the agricultural sector. However, evaluating the existing funds of Pillar 1 in 2017 and the yearly uptake of the Rural Development Programs in the Multiannual Financial Framework (MFF) 2014-2020, one can see some imbalance of funds dedicated to instruments addressing the various objectives. **Table S2.3** and **Figure S2.3** provide an overview on current instruments and funds and how they link to the new CAP-objectives of 2018. Notably, biases in the current budget are anticipated to aggravate given proposed budget cuts on Pillar 2 in the next MFF.

Linking instruments and financial uptake from RDP and the EU-budget 2017 to the new CAP-objective suggests a strong imbalance towards the first objective, which takes about 57.8% of the total agricultural budget. Objective g (attracting young farmers) has the lowest budget (0.8% of the total). Objectives (b) (improvement of competitiveness) and (c) (improving the farmers' position in the value chain) are taken together, since it is not possible to divide the RDP-funds according to priorities 1, 2 and 3 given that these are addressed through a mix of knowledge transfer, innovation, diversification and vocational education.

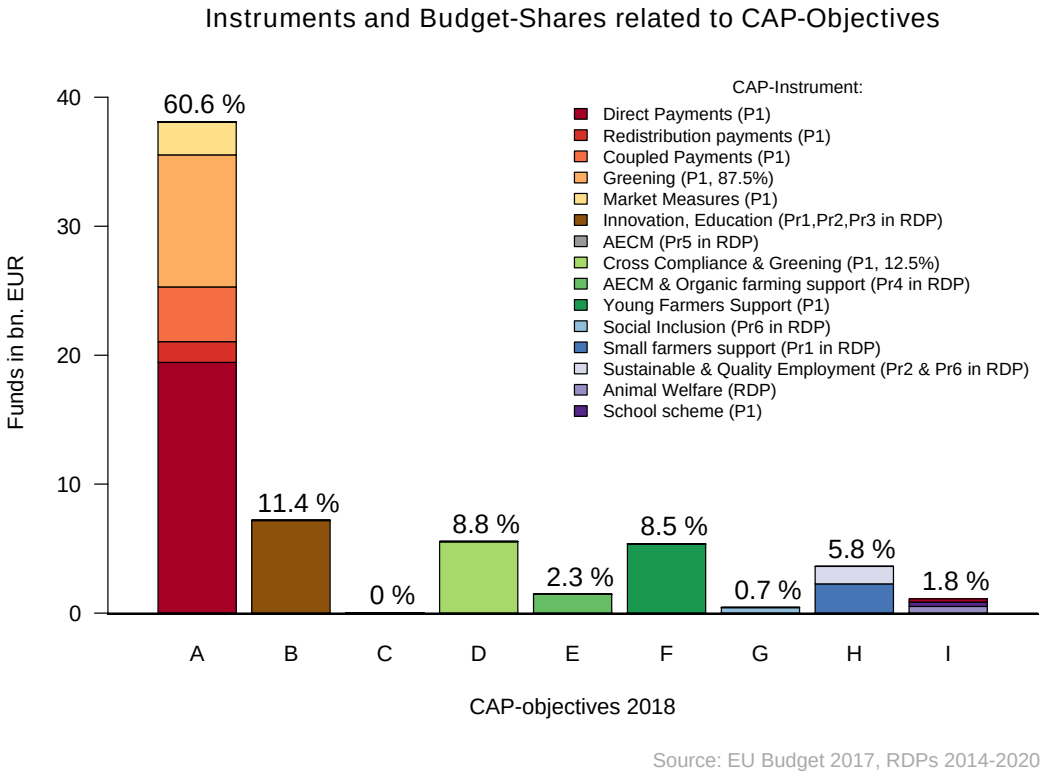


Figure S2.3: Current division of CAP-budgets, linked to the new CAP-objectives of 2018. **Source**: own calculations; for data see SM Table S2.3; **Note:** the proposed objectives for the CAP post-2020 are: A) support viable farm income, B) enhance market orientation, C) improve Farmers' position in the value chain, D) contribute to climate change mitigation and adaptation, E) foster efficient management of natural resources, F) contribute to the protection of biodiversity, G) attract young farmers, H) promote employment, growth, social inclusion, I) improve the response of EU agriculture to societal demands (article 6, (*2*))

Table S2.3: CAP objectives and linked funds 2017 and related instruments

CAP-Objectives 2018	CAP-Instruments and related financial uptake per year in the EU budget 2017 or in the RDP 2014-2020	Share %
(a) support viable farm income and resilience across the Union to enhance food security;	**Decoupled Payments:** 19,442 Mio. EUR [3] **Redistribution payments:** 1,609 Mio. EUR [3] **Coupled Payments:** 4,245 Mio. EUR [3] **Market measures** [5]**:** 2,557 Mio EUR [3] **Parts of Greening**: 10,234 Mio. EUR [3][4] **Sum:** 38,078 Mio. EUR	60.6%
(b) enhance market orientation and increase competitiveness, including greater focus on research, technology and digitalization;	**Priority 1, 2 and 3 and RDP:** Competitiveness of Small and Medium Enterprises (SME), Innovation, Education, Vocational Training: 7,192 Mio. EUR [1]	11.4%
(c) improve the farmers' position in the value chain;		
(d) contribute to climate change mitigation and adaptation, as well as sustainable energy;	**Parts of Agri-environmental & climate Measures (AECM)** (Priority 5 RDP): 5,552 Mio. EUR [1]	8.8%
(e) foster sustainable development and efficient management of natural resources such as water, soil and air;	**Cross Compliance; Ecological Focus Area (EFA)** related to fallow land, landscape elements & buffer strips**:** 1,462 Mio. EUR [3][4]	2.3%
(f) contribute to the protection of biodiversity, enhance ecosystem services and preserve habitats & landscapes;	**Parts of Agri-environmental and climate Measures (AECM)** & **Organic Farming (OF)** (Priority 4 in RDP): 5,360 Mio. EUR [1]	8.5%
(g) attract young farmers and facilitate business development in rural areas;	**Young Farmers** (P1): 441 Mio. EUR [3]	0.7%
(h) promote employment, growth, social inclusion and local development in rural areas, including bio-economy and sustainable forestry;	Social inclusion, **Priority 6** in RDP: 2,274 Mio. EUR [1] **Small farmers support** (P1): 1,347 Mio. EUR [3]	5.8%
(i) improve the response of EU agriculture to societal demands on food and health, including safe, nutritious and sustainable food, food waste, as well as animal welfare.	Sustainable & Quality Employment; **Priority 2 & 6 in RDP**: 514 Mio. EUR [1] **Animal Welfare** 346 Mio. EUR [1] **School fruit, vegetables & milk scheme** (P1): 250 Mio. EUR [2]	1.8%

Source: Own calculation and presentation; The RDP Figures are per annum and refer to the RDP period 2014-2020; RDP Figures are including national Co-funding.

Note: [1]: (*68*) as of January 2019; note that the EC has updated the figures since. **[2]:** (*69*) **[3]** (*70*)

[4]: 50% of the payments relate to maintenance of grassland and crop diversification, which are largely ineffective. The remaining 50% relate to Ecological Focus Area (EFA). In the EU, 25% of the EFA is taken by fallow land, landscape elements and buffer strips [EC 2017], which can be regarded as effective on biodiversity. We take therefore 11 bn. EUR * 50% * 25%, which is 1,462 to objective (e), the remaining greening payments we regard as income support, following the Court of Auditors arguments (*19*). **[5]:** Market measures are 2,806.8 Mio. EUR, subtracted by school fruit, vegetables and milk scheme of 250 Mio. EUR., which leaves 2,557 Mio. EUR.

3. Supplementary Material 3: Balancing instruments and budgets

Statement: The CAP's largest budget share still goes to DP (68.9% in 2017), despite their original design as transitional payment to support farmers following the 1992 CAP reform.

Introduced as "*transitional payments*" in 1992, the original main purpose of Direct Payments (DP) was to compensate farmers for their losses from price decreases during the MacSharry-Reform (1992), Agenda 2000 (1999) and Fischler-Reform (2003) and thus it is unclear what currently justifies their maintenance. In fact, there is lack of evidence for lump-sum income support in the form of DP being efficient to improve farmers' income (*71, 72*). Still, decoupled and coupled payments corresponded to 69.5% of the CAP-budget in 2017 (Figure S3.1).

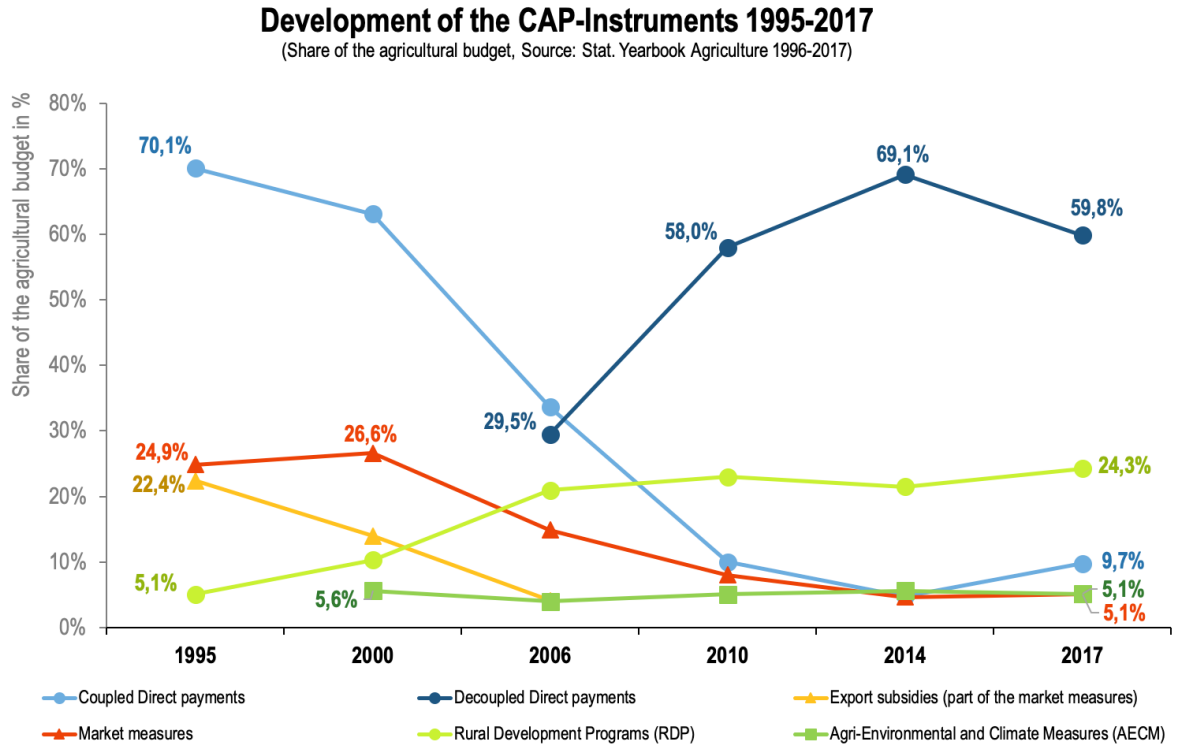


Figure S3.1: Evolution of CAP-Instruments and respective budget shares 1995-2017
Source: own calculations based on data from (*73*).

One issue leading to low effectiveness and efficiency is that DP have a mixed to negative effect on farm production, productivity and technical efficiency (*39, 74-80*). DP influence farmers input- and output decisions (*81, 82*), especially coupled payments and to a lesser extent decoupled DP. While after the Fischler-Reform agricultural productivity in the EU was increasing, the effects of DPs on productivity are still mixed (*83-85*). Thus, despite decoupling, there is still a slightly distorting effect of DP on productivity and efficiency. An increase of coupled-payments' share in the 2013 reform thus reduced effectiveness and efficiency.

Furthermore, DP are inefficient due to an unequal **distribution** across farm size classes, particularly in southern and eastern EU (Figure S3.2). Inequalities increased in eastern EU, partly due to post-socialist changes. This uneven distribution of support suggests that the CAP in general and DP in particular have failed to reduce disparities and achieve a fair standard of living of farmers (*28, 32, 86*). The employment of 'capping and redistribution' in the 2013 reform has not led to decreases in inequity-levels of the payments either (among farm classes; Figure S3.2). Additional inefficiencies result from leakages of DP to increased land rents (*87-97*).

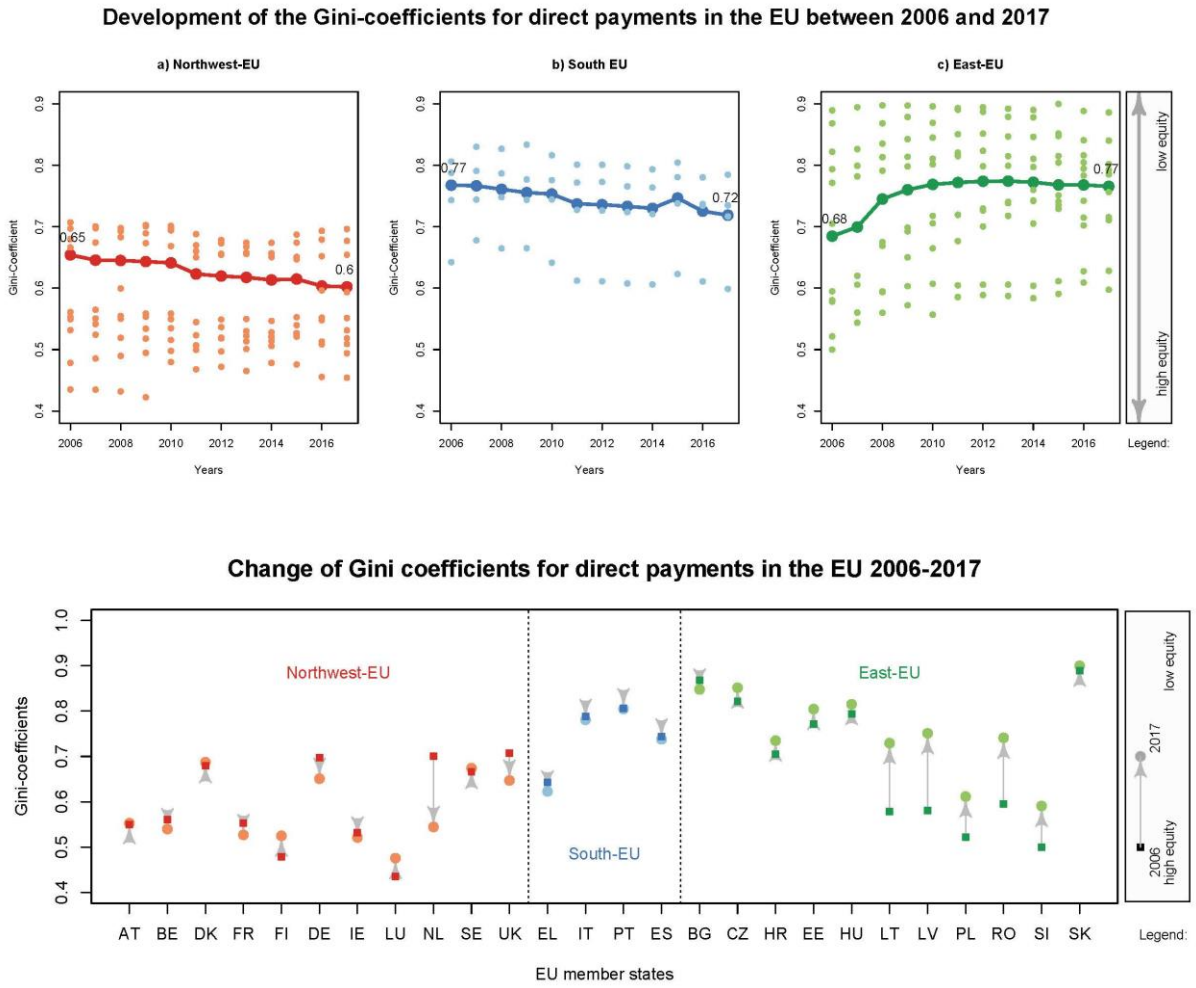


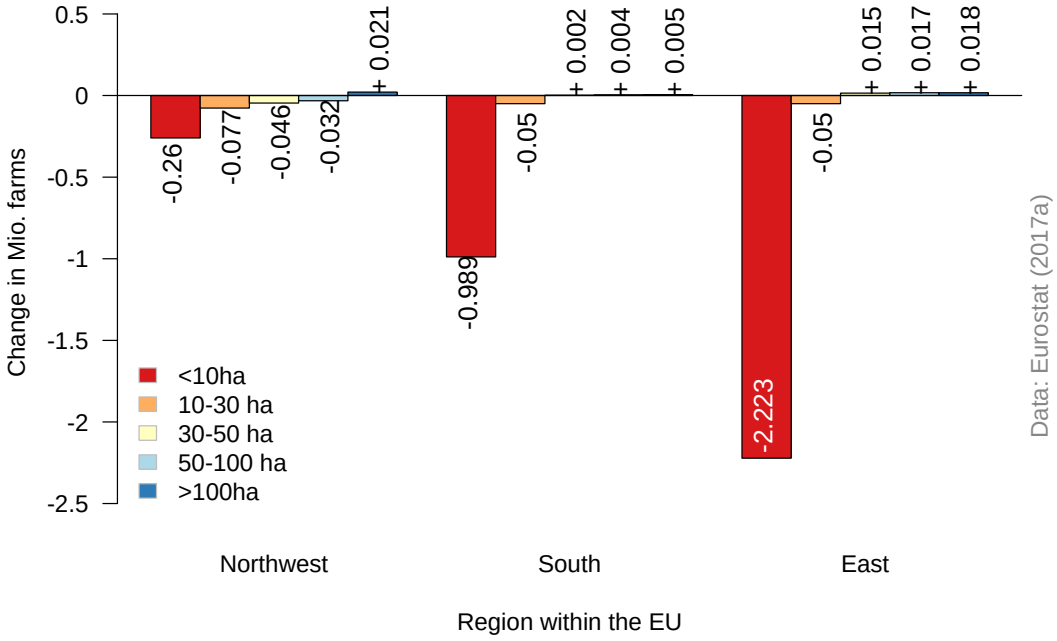
Figure S3.2: Distribution of direct payments in the EU 2005-2017 across farm size classes, summarized using the Gini-coefficient of inequality.

a) Development of the Gini-coefficient in West, South and East EU,

b) Changes of the Gini-coefficient between 2006 to 2017 across MSs.

Source: Own calculations based on data from (*98*). ***Note****: The Gini-coefficient is a measure of inequality, ranging from 0 to 1. The higher the value is, the more uneven is the distribution of payments across farm-size classes.*

Structural change has been shown to be a constant development in Europe as well as in other industrialized countries. The following Figure S3.3 shows the change in number of farms within different size classes between 2005 and 2013. Direct payments are an inefficient instrument to support this structural transformation of rural area, to support farmers moving out from farming, or to support farmers expanding and diversifying their businesses to other activities such as rural tourism, services or forestry (*99*).



Changes in farm numbers among farm sizes 2005-2013

Figure S3.3: Continued change in the number of farms, particularly among small farms at risk of poverty in new member states;
Source: own calculations, data from (*100*)

Statement: Highest investments are made into the least effective Greening compared to the more effective AECM [and] the most targeted Natura 2000-investments into protected areas

Greening was introduced as an ambitious set of environmental rules linked to DP. However, through a large set of exemptions (setting low demands and including options with low effectiveness), greening has become largely ineffective (*43, 101*). Introduction of flexibility to MSs and farmers reduced the effectiveness of Ecological Focus Areas (EFA) at two levels, one being MSs' choice of possible options to offer at the national level, and the second is farmers' choice of actual options to implement (*27, 101, 102*). Several production-oriented EFA options have low potential for biodiversity protection, such as catch crops and the option to apply pesticides for some EFA-options (abolished in 2017). The option of buffer strips, despite its high potential effectiveness for biodiversity, was only implemented in 17 out of 28 MSs (*3, 103*). Uptake options by farmers favored simple, productive options (*104*), despite their lower effectiveness. Consequently, over 70% of EFA cover within the EU was under less

effective or ineffective EFA-options (*4, 105*). Thus, the decision to allow flexibility reflected as a large number of options resulted in a cumbersome instrument with low effectiveness and efficiency (Table S3.1a; and (*3, 101, 104*)).

Spending on climate measures within AECM is marginal to needs, and targeted actions do not address the main agricultural greenhouse gas (GHG) sources, namely livestock farming (responsible for over ⅔ of agricultural GHG emissions), nitrogen fertilizers and the drainage and intensive land-use on high organic soils. In the proposed CAP, the contribution of agriculture to climate change is not explicitly acknowledged and the main sources of GHG emissions remain unaddressed. Following GHG declines until 2005 (as side-effects of other policies), agricultural GHG emissions stagnated or even increased (see Fig. S4.1). However, the main trend in GHG reduction cannot be linked to any targeted measures within the CAP for two reasons (*106*): A change in bovine cattle numbers (from approx. 94 in 2001 to 89 million in 2015) related to decoupling and the milk quota regime; and N-fertilizer use, with earlier reductions because of the Nitrates Directive as "Statutory management requirements" under Cross Compliance (CC) (*107, 108*).

After a long stagnation in AECM budgets, the 2013 reform and establishment of greening has eroded AECM budget, with the total funding declining between 2014-2020 by 8.6% (conservative estimate not considering inflation and a previous budget increase for AEM in 2009/2010; Table S3.1b).

Table S3.1a: Area and spending of the EU for different environmental instruments in 2017.

Policy measure	Agricultural Area (in Mio. ha)	Public funds (in Mio. EUR)	Relation funds to area (EUR/ha)
Greening: **Ecological Focus Area (EFA)[1]**	8.00	12.638,21	**789.89**
Agri-Environment-Climate Measures (AECM)[2] (Including areas and payments for organic farming, but without payment for areas with natural constraints)	13.15	3,250.92	**247.17**
Natura 2000[3] (Grassland area in SCI reported as by the EU commission)	11.65	290.00	**24.89**

Source: Own presentation; Data (EU Commission 2015, 2017b; Eurostat 2010)

Note: (1) The sum of all EU national ceilings per year is on average 42.127 Mio. EUR. If multiplied by 30% one obtains 12.638 Mio. EUR. The 8.00 Mio. ha is thus the real area, i.e. prior to applying weighting factors. We are assuming that only 50% of the Greening payments of 12 billion EUR goes into EFA. Otherwise, payment per hectare would be 1,579.78 EUR/ha. **(2)** Payments are without national co-funding. **(3)** Natura 2000 and Agri-environmental programmes are partly overlapping in terms of area and funding. Eurostat lists 11,652,978 ha as SCI targeted agricultural habitats.

Table S3.1b: Changes in Agri-environmental & Climate Measures (AECM) funding as share of Rural Development programmes (RDP) over the last reform.

Funding	RDP 2007-2013[1]		RDP 2014-2020		Change	
	Spending (bn. €)	Share (%)	Spending (bn. €)	Share (%)	Spending (bn. €)	Share (%)
Sum Rural Development Programmes	22,115		22,228		0.113	0.51%
Agri-environmental & Climate Measures[2]	5,375	24.30%	4,915	22.10%	-0.461	-8.57%

Source: Own calculation; Data 2007-2013 are from (*109*) (*110*); Data 2014-2020 are from country sheets for the RDP 2014-2020.

Note: (1) Figures are average yearly expenses for the EU-27. Croatia is not included. The RDP-figures are including Co-financing by member states and include technical assistance. Budget increases of the Mid-term-review-reform 2009 are not included. Note also that figures are not deflated. Therefore, this decrease is a conservative estimate. **(2)** Figures for Agri-environmental & climate measures include payments for organic farming but do not include payments for less favoured areas (LFA, now referred to as "Areas facing Natural or other specific Constraints" (ANC)).

Statement: *The proposed CAP includes a 28% budget cut for Pillar 2 which expands DP to 73% by 2027, without providing clear justification for their maintenance*

Due to Brexit, budget cuts are inevitable as the UK has been one of the EU's key net-contributors to the EU-budget. The proposal for the EU's Multiannual Financial Framework (MFF) 2021-2017 foresees **substantial cuts for Rural Development Programs (EAFRD)**. The EC has claimed in its communication that the CAP's spending will be reduced by around 5% (*105*). However, after taking into account considering inflation, the late approval of the Rural Development Programs 2014-2020 and the phasing in of DP in Croatia, (*21*), concluded that the new MFF 2021-2027 proposes a cut of DP in Pillar 1 by 12%, whereas Rural Development Programs (Pillar 2) will be cut by 28% (*Table S3.2*).

Table S3.2: Comparison of the last year of the MFF 2014-20 and 2021-27

	MFF EU 27 ceilings		Change 2020-2027 (%)
	2020	2027	
EAGF (Pillar 1)	39.468	34.606	-12,3%
EAFRD (Pillar 2)	13.050	9.421	-27,8%
Total CAP	52.518	44.027	-16,2%

Source: (*23*): **Note:** EAGF = European Agricultural Guarantee Fund (funding source of Pillar 1), EAFRD = European Agricultural Fund for Rural Development (funding source of Pillar 2).

A disproportionate budget cut would result in an **increase of the share of direct payments** for in the next CAP. Assuming that the market measure be constantly about 5% of Pillar 1, the share of DP will increase to 73%. This increase conflicts with strong evidence that strengthening Pillar 2 represents the best way to improve the CAP performance along most socioeconomic and environmental criteria (*11, 111, 112*).

Statement: *The proposed update to the 'capping and redistribution' mechanism remains weak, because labor costs can again be deducted from farmers' income in a way that continuously lifts the capping threshold*

To address criticism regarding the biased distribution of payments, the EC proposes implementing a stricter "Capping" (Article 15) than the one currently installed, starting at 60k €/farm and reducing payment rates by 25%, 50%, 75% and finally reaching complete capping of payments beyond 100k €/ farm. The shortened payments can be used for redistributive payments for first hectares ("Complementary redistributive income support for sustainability", in Article 26). This should supposedly favor farms with small land endowment. Yet according to Article 15 (*113*), salaries linked to agricultural activities (incl. taxes and social contributions) can be deducted, including equivalents for unpaid labor. (*20*) highlights that, while on first view Capping appears stricter compared to the current CAP (2014-2020) due to the lower entry level (60k €/farm instead of 150k €/farm now), the deduction of salaries might create a loophole where the increase in area is parallel to the increase in labor (and with it, salaries), so that Capping becomes meaningless. Moreover, through the deduction of salaries, DPs may now not only distort land-use but also labor markets for large farms, since there would be an incentive to adjust salaries in order to avoid Capping. Regardless, even if Capping would really lead to improvements in payment distribution compared to 2014-2020, it will not resolve the problem of a missing justification of DP as a whole.

Statement: Payments linked to the production (coupled payments) are maintained despite forming a key obstacle to environmental sustainability and undermining the common market

Coupled Payments with DP served as an instrument to reduce income losses by the MacSharry-Reform (1992) and the Agenda 2000 (1999). Following the Fischler-Reform of 2003, coupled payments were slowly reduced in order to address criticism by the WTO and change the support from so-called *blue box* into the *green box* according the GATT Uruguay round agreement of 1994 (*114, 115*). In 2013, following the Health Check-reform 2009, the level of coupled support was reduced to 6.5% of the total DP in 2014.

The 2013 reform of the CAP ('Ciolos-Reform') reintroduced coupled payments "Variable Coupled Support (VCS)" for specific farm types and agricultural sectors of economic importance undergoing certain difficulties. MSs could use between 8% and up to 13% of their

ceiling to this end, and pay 2% of the ceiling as Voluntary Coupled Support (VCS) for protein crops (*25*), article 52 ff.). This led to a reversal in the trend (Figure S3.4), where almost all MSs made use of VCS, with higher shares observed in Malta (71.2%) and Romania (20.8%). The largest part of VCS supports Beef and veal (40%), and milk and dairy products (19%) (*65*).

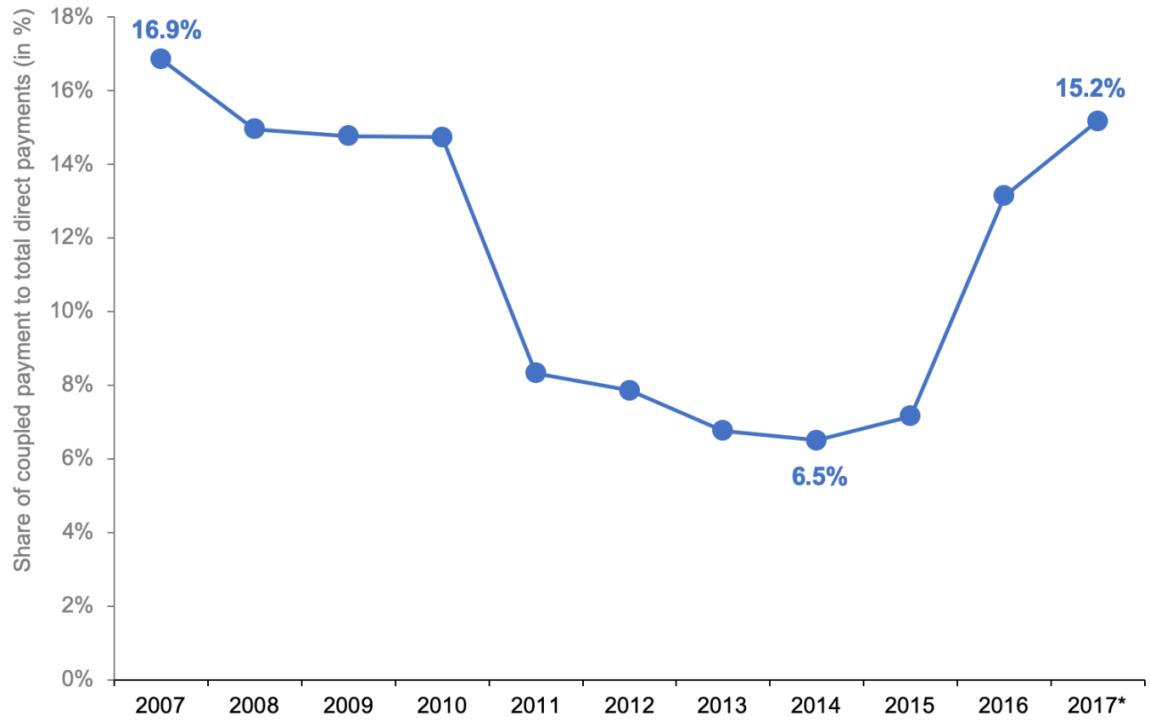


Figure S3.4: Share of Coupled Payments within all Direct Payments 2007-2017 (in %)

Source: own calculations, based on (*116*) and Budget data from the EC, **Note**: *2017 are preliminary data;

Influencing farmers' input- and output-decisions is especially problematic with coupled payments. The literature suggests that coupled payments reduce technical efficiency even more than decoupled payments (*39*). The proposed scope, design and financial shares for the next CAP within Pillar 1, will *de facto* not change compared to 2014-2020. This decision disregards criticism of OECD (*114*) for reviving this instrument, and a breadth of evidence (*11, 24, 117-120*) indicating that coupled direct payments are particularly distortive of farmers' input decisions, reducing farm efficiency and contradicting the objective of this instrument. Coupled direct payments also maintain a complex support structure without providing outcomes for taxpayers and citizens, motivating lobbyism by farmers associations, who seek to maximize support for specific sub-sectors in agriculture (see, for example in Bulgaria (*119*)). Maintaining coupled support is a critical point in the proposed CAP post-2020 (*11, 24, 118*), and an outcome of flexibilities for the MS within the Cioloș-Reform of 2013 (see section SM 2).

Statement: AECM budgets are reduced, and budget shifts from Pillar 2 to Pillar 1 are allowed

Several financial mechanisms in the proposed CAP may weaken the ***Green Architecture*** of the CAP post 2020 in less ambitious MSs:

- **Allowing any budget shifts from Pillar 2 to Pillar 1** can result in further declines of AECM budgets in many MSs, as was already observed after the 2013 CAP reform (see (*121*): p. 4). At the same time, setting a **limit on the shifts from Pillar 1 to Pillar 2** sends a wrong signal to MSs given that a) the public clearly expressed a wish to see greater support for rural areas and the provision of public goods (e.g. high quality food and environmental services (*8*)), and b) models and other evidence indicate that moving as much of the budget to Pillar 2, while simplifying administrative burdens on AECM (see below), is likely to be the best scenario for the CAP's improvement.
- **Environmental ring-fencing:** MSs have to dedicate 30% of Pillar 2 (EAFRD) to environmental and climate targets as in the EAFRD 2014-2020. This remains little, given that the total EAFRD budget will likely decrease by 28%. Therefore, ring-fenced amounts might be reduced to 21.8% compared to the EAFRD 2014-2020. The final amount for environmental and climate targets strongly depends on the decisions of the MSs and their use of the flexibility to shift budgets between pillars.

We note that payments for **Areas with Natural Constraints (ANC)** are proposed to move out from Pillar 2 into Pillar 1, affecting the overall performance of Pillar 2. ANCs are a specific point in case because, while communicated as "environmental measure", there are no specific environmental requirements linked to these payments. In fact, some studies regard ANC payments as "additional direct payments" for farmers in marginal regions, with no visibly positive environmental effects ((*122*) pp. 144-146),(*24*). On the ground, their impacts vary strongly between MSs depending on their decisions, ranging from positive to negative (*7, 123, 124*). The option of shifting these payments (comprising 16.8% of the spending within the RDPs 2014-2020) into Pillar 1, can therefore be considered as a potential improvement as it may leave more funds to AECMs (depending on MSs' decisions).

Recommendation: To address societal demands, investments in CAP instruments should be balanced according to their environmental and socioeconomic performance

CAP payments should meet real socio-economic needs, be allocated to farmers who need support, link to clear objectives (see *125*), and evaluated against measurable, quality-related results. This means that the amount of financial resources should be derived from societal and political priorities, rather than (as it has been observed in the last reforms) predetermined reform-outcomes (see below). Accordingly, decisions with respect to the proportions of Pillar 1 and 2 should be met in view of their contribution to societal, economic and environmental

dimensions of sustainability. This would inevitably lead to **strengthening Rural Development Programs** (RDS; Pillar 2) given their broader scope not only for agriculture, but also for the environment, sustainable food systems and the livelihoods of villages and rural areas. Strengthening Pillar 2 may require not only increased budget shifts but also a revision of the co-funding requirements, and accepting the higher administrative burdens due to the application of Pillar 2 measures and programs (*123, 126*).

In the long term, income support should **focus on vulnerable and close-to-poverty farm households**. In some MSs, specifically in the Eastern EU (e.g. in Romania, Poland or Bulgaria, see (*119*)), such farms provide public goods, thus demonstrating a strong link between social and environmental objectives (*127*). They rely on support to maintain economic, social and cultural conditions in rural areas (*127, 128*). Household-based concepts to measure "poverty risks" are available (e.g., 60% of median income, see (*129*)), however, the EC should provide reliable statistical evidence to this end.

Particularly, performance evaluation requires employing better indicators of farm income and accordingly, which farm households need support. It is necessary to consider other income sources from outside agriculture, of the entire household. Additionally, one has to include private and farm assets (*130*), and consider differential living costs. This could be addressed by resolving some methodological issues in the EU Farm Accounting Data Network (FADN) as the main data-source regarding farm income (*71*).

Recommendation: DP need to be gradually phased out in favor of a system that balances all CAP objectives and supports farmers in need that are engaging in sustainable and environmentally-friendly farming

Experiences with payment schemes in both developed and developing countries show that often political power struggles and administrative burdens undermine effectiveness and sustainability of incentive systems (*131*). Thus, attempts to fully integrate environmental aspects in DP may prove to be difficult, as demonstrated by the watering down of Greening in the 2013-reform.

Given a much greater range of instruments to support both environmental aims and rural development issues in Pillar 2, and in light of poor justification and distortive impacts on markets, **Direct Payments should be phased out** and replaced by targeted payments to support rural areas and the provision of public goods on agricultural lands (*3, 11, 24, 112, 123, 132, 133*). This is specifically true for **coupled payments** given their distortive effects on management and markets. Examples can be taken from the experience in Switzerland and the proposed changes in the UK.

In **Switzerland**, the focus on public goods like biodiversity or landscape quality are established from the 1992 reform onwards (*134*). A recent study could show that the 7% biodiversity promotion areas achieve positive impacts on butterflies and birds (*135*).

In the **United Kingdom**, DEFRA is currently designing such a phase-out of direct support and an increase of funds linked to public goods (such as better air and water quality, improved soil health, higher animal welfare standards, public access to the countryside and measures to reduce flooding), which can serve as an important example for the EU to follow (*136*). Under the new system, support will be related to produced public goods and farmers and land managers who provide the greatest environmental benefits will secure the largest rewards.

As long as DP are retained, they should strictly link to public goods such as environmental friendly or sustainable farming system (*11, 24, 29, 132*). Specific sector support should be justified by potential market failure or in single cases by extreme events e.g. extreme weather conditions. Otherwise, such support should be reduced to improve the level playing field within the EU market and in view of trade partners (*137*).

Recommendation: In the short term, a larger proportion of the budget should be secured for AECM and Natura 2000 payments within Pillar 2, and for new voluntary 'eco-schemes' within Pillar 1. MSs should be granted unlimited flexibility to shift budgets from Pillar 1 to Pillar 2, particularly to AECM

For the CAP post-2020, the limitation of 30% budget transfers from Pillar 1 to Pillar 2 should be cancelled, while transfers from Pillar 2 to Pillar 1 should be limited or prohibited (Article 90), as proposed by the EP's Environmental Committee (*138*). Combined with adopting published recommendations for Pillar 2 simplification and increasing attractiveness for AECM (e.g. incentives for higher performance), both an improved performance and reflection of public demand for environmental protection (*11, 139, 140*) and socioeconomic challenges in rural areas can be achieved (*141*). Specific AECM measures targeting biodiversity and landscapes should be increased to support endangered species, habitats and overall biodiversity (*123, 140, 142, 143*).

Financial requirements (Ring Fencing): it is proposed that at least 30% for all environmental measures in both pillars and at least 40% funds within the Rural Development programs (Pillar 2) should be required to fulfil the objectives listed under Article 6 in the legislative proposal. Budgets released by 'Capping' should be used for eco-schemes or shifted to Pillar 2.

Specific Ring fencing for biodiversity: Funds should be earmarked particularly for AECM and Natura 2000 payments within Pillar 2, with proposed financial amounts of 15 bn. EUR/year from the EU and 5 bn. EUR/year by MSs.

Additionally, within their strategic plans, MS should provide a clear strategy for integrating the new voluntary 'eco-schemes' in Pillar 1 with AECM and Natura 2000, incentivizing farmers to provide environmental services beyond basic requirements (e.g., enhanced management of pastures and landscape features) and ensuring complementarity both in contents (i.e., which measures are implemented) and in geographic distribution to achieve larger scale aims and to support the EU's Green Infrastructure strategy.

4. Supplementary Material 4: Sharpen the Green Architecture

Statement: The proposed new 'Green Architecture' seems weaker than in the current CAP

Some elements of the proposed Green Architecture could be considered as an improvement, such as the inclusion of some important "Good Agricultural and Environmental Practices" (GAEC) under CC, and the establishment of voluntary Eco-schemes in Pillar 1. However, a systematic assessment of the Green Architecture reveals an overall potential for weakening environmental performance.

1. Enhancing CC retains the basic flaw of low sanctioning power

The literature indicates little incentive for farmers to comply with CC given the presently weak combination of controls and sanctions (*144, 145*). Implementation of CC is particularly hampered by the fact that penalties of up to 5% farmer's annual payment entitlement are considered too low to deter against non-compliance (*145*), and thus it does not effectively halt habitat loss and quality (*146*). Additionally, control of implementation is limited: for instance, there was no evidence of farmer penalization for habitat clearing across 12 MSs (*147*). It has also been reported that farmers might adapt their management, for example by removing vegetation in semi-natural habitats in order to avoid risks of losing CC payments due to lack of knowledge, leading to non-compliance with eligibility rules (*147*). Thus, the focus on expanding CC entails a decline in sanctioning power, while hampering the EU's obligation to deliver public goods beyond cross compliance (*148*)(action 8a).

2. Greening measures are integrated into the CC mechanism, without defining specific measures, rather than sharpened as recommended in the literature

Several assessments of the Greening measures suggested that they have the potential to become more effective if sharpened and improved, by removing some of the broad exemptions (e.g. due to area thresholds; (*43*)), excluding ineffective EFA options (*3, 104*), promoting collaboration instead of fragmentation (*149*) and setting clear management requirements (e.g. prohibiting pesticide use). The proposed CAP post-2020 does not fully clarify what is the follow-up of Greening requirements but it seems that these will be partly included under Cross Compliance and Eco-Schemes. Accordingly, the number of "Good Agricultural and Environmental Practices (GAEC)" increased and new "Special Management Requirements (SMR)" were added. This restructuring is referred as "enhanced conditionality" (*150*). However, the fate of EFAs is unclear, and the lack of specification in terms of implementation options goes against the recommendation to clarify greening measures and reduce vagueness that can translate into MSs and farmers adopting the simplest and least effective measures.

3. Some environmental safeguards are cancelled (e.g., to avoid negative impacts of irrigation)

The literature indicates that CAP has a mixed contribution to the share of irrigated land, and respective negative environmental impacts. While environmental instruments attempt to reduce water consumption (e.g. GAEC standards, AECM), CAP also support the expansion of water-demanding crops (*151*). In the Mediterranean region, CAP contributed to the increase of olive production fostering mechanization and irrigation (*151*). However, Article 46 of the current CAP, including a detailed list of safeguards to avoid negative impacts of irrigation, has been completely deleted instead of expanded or improved. It is now stated that MSs need to make a list of irrigation investments to be excluded. By placing an existing regulation at the hand of the bodies that the regulation is aimed at, the door is opened for potentially-unrestrained funding of irrigation-expansion, including in stressed watersheds where this could lead to environmental degradation (e.g. drainage of wetlands or replacement of dryland habitats). This contrasts to Objective e, i.e. “efficient management of natural resources such as water, soil and air”.

4. Several sectors and instruments are exempted from environmental requirements.

Various instruments and payments are exempted from environmental criteria. These include coupled support, investment measures, and sectoral supports such as olives, wine and cotton. Similarly, assistance to young farmers does not require adopting environmental standards. Such inconsistencies in the CAP allow intensification with no restriction, thus ignoring repeated recommendations to withdraw harmful subsidies and exemptions (*11, 24*) in line with the CBD’s Aichi Target 3.

5. AECM are weakened by the inclusion of new, but vague, management options (with reduced budget)

Most ecological studies targeting CAP impacts focus on Agri-Environment-Climate Measures (AECM), including many examples of good implementation as well as barriers to effectiveness and efficiency. The literature indicates that local successes cannot scale up to the EU-level due to limited budget, poor design and implementation, and scarcity of landscape-level planning and implementation (*149, 152-154*). Furthermore, the requirement of co-funding made them unattractive to many MSs, whereas administrative burdens led to low uptake by farmers in favor of simpler DP (*111, 155, 156*). Notably, administrative burdens can reach to 30% on top of the costs for dark-green measures (*155, 157*). The proposed CAP does not resolve these issues, further weakening AECM by reducing Pillar 2’s budgets while including new vagueness by allowing MSs to include “other management commitments” (Article 65) yet without defining aims and criteria for inclusion of such commitments.

Another key weakness of AECM which remains unaddressed is the failure to transform AECM into actual incentives for farmers or to improve the economic state of vulnerable farmers (as is potentially done using DP). This will continue discouraging AECM uptake.

6. 40% of the CAP budget 2021-2027 is labeled as 'climate friendly' without appropriate measures targeting the largest GHG emission sources, namely livestock production

The overall trend, showing an increase in EU's agricultural GHG emissions since 2012 (Figure S4.1, does not reflect a visible effect of current instruments under the CAP. This trend relates mainly to: changes in bovine cattle numbers (from approx. 94 in 2001 to 89 million in 2015)(*158*), resulting partly from decoupling and the milk quota regime; and development of N-fertilizer used, with earlier reductions because of the Nitrates Directive as "Statutory management requirements" under CC (*159*).

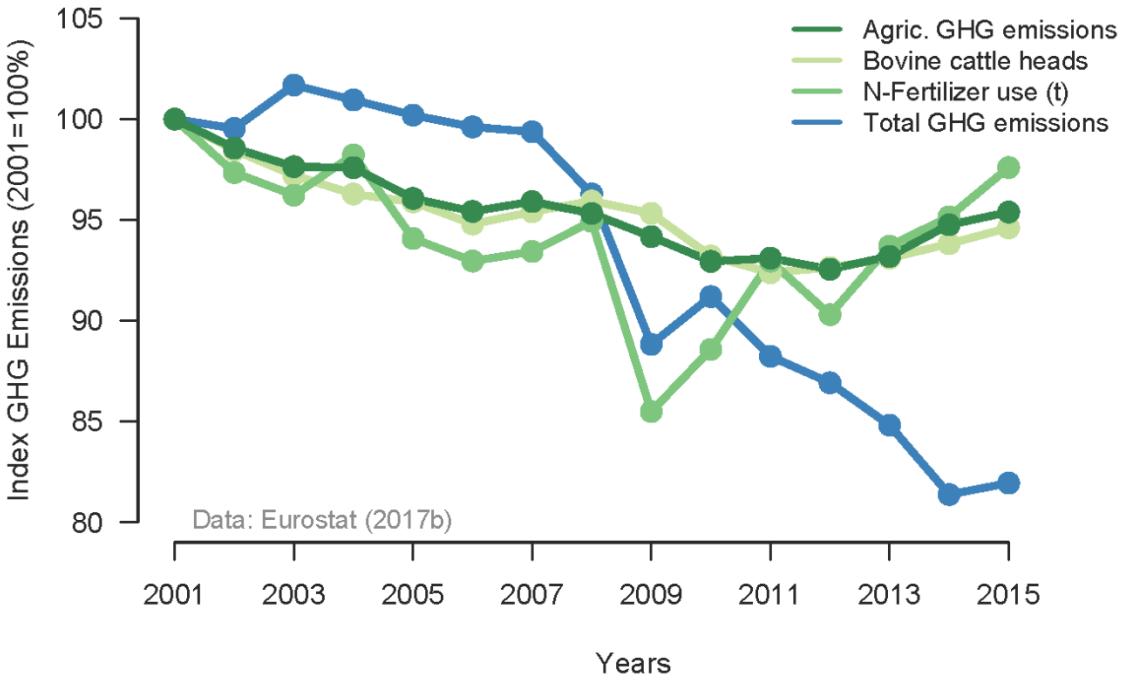


Figure S4.1: ***GHG emissions at the EU level are slowly declining, but agricultural GHG emissions are stagnating and have even recently been increasing, in line with bovine cattle production and N-fertilizer use*****.**

Source: Eurostat (2017b)

Instruments directly addressing major sources of agricultural GHG emissions sources are lacking. This is particularly true for livestock farming, responsible for over ⅔ of agricultural GHG emissions, also partly due to land-use change outside the EU for the production of imported feedstock. While studies on emission reduction potentials and abatement costs are available (*160*), a comprehensive analysis performed for the EC indicates a lack of instruments to tackle EU's agricultural GHG (*9*).The legal framework of the proposed CAP explicitly refers to the Rio Markers approach, according to which 40% of the CAP's budget 2021-2027 will contribute to the targets of the Paris climate agreement. In figure 52 of the reform proposal, the EC states "*Actions under the CAP are expected to contribute to 40% of the overall financial*

envelope of the CAP to climate objectives" (*2*). However, a large proportion of so-called "climate funding" under the CAP is supporting measures with little contribution to climate change mitigation (*103*). This is particularly due to conditionality, allowing DP to be largely defined as climate spending even under measures supporting climate-intensive sub-sectors like large pig- or beef-farms. This approach is misleading the public about CAP-outcomes, as already pointed out (among others) by the European Court of Auditors (*19*) and the recent EC report on climate (*9*).

Recommendation: The CAP post-2020 needs a green architecture built on well-defined measures and a strengthened Pillar 2

1. **Sharpen Green Architecture elements in Pillar 1**

Clarify the fate of the greening measures and take up lessons and recommendations based on the CAP 2014-2020. EFAs will gain in simplicity and efficiency by cancelling options not supporting biodiversity, which are implemented anyway by farmers e.g. catch crops and nitrogen fixing crops. Replacing 'crop diversification' with 'crop rotation' can have some advantages, yet it entails that no requirements will exist to halt the ongoing shifts to large-scale monocultures. A targeted measure is thus needed to maintain or increase crop diversity relatively to current levels. Protection of permanent grasslands out of Natura 2000 is still required by setting criteria and indicators for management (livestock densities) and quality.

'**Eco-scheme**' should be based on dark-green measures i.e. measures scientifically proven to be highly effective and needs to be coherent with AECM in Pillar 2 to ensure complementarity between instruments.

Restore Article 46 of the current CAP regarding safeguards to avoid undesirable environmental effects of irrigation

2. **Enhance landscape-level implementation in both pillars**

Evidence points at very high potential to enhance effectiveness and efficiency through more coordinated actions among farmers to achieve landscape-level targeted measures rather than farm-level ones (e.g. *149, 161, 162*). Furthermore, expanding measures to enhance and maintain the multi-functionality and structural diversity of agricultural landscapes will benefit biodiversity while enhancing the effectiveness of measures aimed at reducing within-field land-use intensity across landscapes (*149, 161, 163, 164*). Promoting larger-scale coordination could be achieved through refinements of the three most relevant Articles:

- For AECM (Article 65 (7)), it is recommended to make collaboration obligatory for MSs by e.g. replacing "*may*" with "*shall*". An even better path may be to set a target that, by 2027, at least 10% and optimally 30% of AECM payments should be landscape-targeted.
- Eco-schemes (Article 28) should include a section prioritizing payments towards collective implementation, or even more explicitly propose additional payments to incentivize geographic clustering supporting habitat connectivity and the EU's Green Infrastructure strategy.
- Article 71 ('Cooperation') should bind payments to environmental objectives.

3. **Increase support for High Nature Value (HNV) farmland and Natura 2000**

Eligibility rules (e.g. farm size) should be revised to include HNV farmers, making them beneficiaries of distinct environmental support schemes e.g. AECM and Natura 2000 payments. Supports targeting specifically HNV farming systems should also be implemented Moreover, given the importance of Natura 2000, it would be appropriate to increase this type of spending, as proposed by the EU Parliament on December 11, 2018 (*165*).

Recommendation: In the short term, harmful subsidies (e.g. coupled payments) should be eliminated and all instruments should be aligned with sustainability criteria

Only some CAP instruments, particularly coupled direct payments, can be categorized as harmful subsidies. Others, however, may have unintentional impacts. To avoid the risk of some instruments being harmful subsidies, it is important to include environmental criteria for eligibility, coherent with environmental objectives, in articles where these are lacking. Examples include:

- Investments in Pillar 2 (Article 68);
- Sectoral supports to wine (Section 4, article 51), olives (Section 6), cotton and renewable energy;
- Article 59 (Objectives in other sectors) - which currently only relates to some objectives (a,b, c and i);
- Areas of Natural or other area-specific constraints (Article 66); and
- Installation of young farmers and rural business start-up (Article 69).

Recommendation: Instruments in both pillars should be refined to support landscape-targeted and coordinated actions among farmers to reach larger-scale goals such as improved landscape connectivity and supporting farmers in HNV areas.

Empirical studies demonstrated that spatial targeting and design can optimize AECM towards a better use of investments (e.g. (*166*)). Local initiatives (e.g. “coalitions” in The Netherlands) may help integrating farming and environmental production within the concept of “landscape governance”, going beyond the farm-based implementation of AECMs (*15, 101, 142, 154, 167-169*).

Modelling and simulation tools to support the design of landscape-targeted (and coordinated) AECMs were proposed to reduce administrative burdens and increase collaboration among farmers (*149, 170, 171*). Case studies indicate that **result-based approaches**, where farmers are paid for biodiversity outcomes rather than for specific management prescriptions, may be more challenging and potentially less intuitive, but they can become operational and lead to higher effectiveness, as well as cultural change and social learning (*172*).

Two instruments in the proposed CAP relate to potential implementation at larger-scale level, i.e. by groups of farmers, namely Article 71 ('Cooperation') and Article 65(7) (AECM, MSs "may promote and support collective schemes and result-based payments schemes to encourage farmers to deliver a significant enhancement of the quality of the environment at a larger scale and in a measurable way"). However, Article 71 does not necessarily relate to environmental objectives and may even promote unsustainable farming practices such as larger-scale operations (i.e. homogenization). Article 65(7) is voluntary for MSs to adopt; and therefore, based on current implementation one can assume that most payments will continue focusing on farm-level, and hence less effective, actions.

The current CAP allows MSs to support collaborative implementation of greening measures as well, but only two MSs have taken up this option (the Netherlands and Poland). In the proposed CAP, however, there are no clear instruments in Pillar 1 relating to larger-scale implementation, neither as Cross-Compliance mechanisms nor in Eco-schemes (Article 28). Thus, the proposed CAP goes a step away from contributing to landscape-level implementation.

Recommendation: In the longer term, the mandate of AECM should shift from just compensating income foregone (i.e. opportunity costs due to implementing farm management beneficial to the environment) to rewarding the delivery of public goods in a way that makes such investment profitable and attractive for farmers

The CAP exhibits a poor balance between incentives and sanctions for delivering public goods and only weakly applying the 'polluter pays, provider gets' principle. While Pillar 1 with DP and greening hardly incentivize more sustainable land-use (*3*), one key critique on Pillar 2 the effectiveness of Pillar 2 and AECM relates to the limitation of payments to merely compensate compensating for income foregone which makes them unattractive for farmers (*123, 126*). The implementation of sanctions has been shown to be ineffective as well, not only for CC (*144, 145*) but also for EFA options under greening, such as buffer strips, whose complexity may induce sanctions if implementation is not accurate enough (*104, 173*). A combination of approaches, to include both incentives and sanctions, may prove more effective and can be based, for example, on a pointing system as proposed by some farming organizations.

5. Supplementary Material 5: Link the CAP to real impacts

Statement: The CAP has been increasingly criticized for its administrative complexity

The CAP offers as multitude of instruments with differing and even conflicting targets, while other instruments overlap in aims but compete in performance. This has resulted in a highly complex policy imposing excessive administrative burdens. Particular particularly issues occur in Pillar 2 due to the larger number of instruments as well as co-funding requirements. Administrative burdens and conflicting requirements with respect to environmental measures (*173, 174*), have led to low uptake of voluntary measures like AECM (*175*) and favoured the selection of simple but less effective EFA options by farmers (*104, 176*). There is some substantial variation of administrative overheads though: A case-study comparing four federal states in Germany found the administrative (or 'implementation-') costs of RDPs to range from 7.8% of the total expenditure in Lower Saxony to 18.6% in Hesse (*155*).

Comparing both Pillars, in Baden-Württemberg, Germany, administrative costs (overheads) ranged from 7.4% for the European Agricultural Guarantee Fund (EAGF; Pillar 1) compared to 29.1% for the European Agricultural Fund for Rural Development (EAFRD; Pillar 2) (*157*).

Greening (in Pillar 1) also required the additional employment of 250-300 administrative staff in Germany (*177*). However overall, in the CAP 2014-2020, administrative costs for Pillar 1 measures (including Greening) are still less costly.

The asymmetric structure of administrative costs, combined with co-funding requirements, incentivizes MSs to prioritize Pillar 1 and to transfer funds from Pillar 2 to Pillar 1, particular for new (Central and Eastern) MSs where public budgets are under pressured (Poland, Hungary, Slovakia, Croatia, Malta) (*121*).

Statement: The CAP post-2020 proposal for a new, 'results-based' delivery model gives flexibility to MSs to deliver results rather than complying with prescribed requirements

While flexibility is essential to allow MSs and regional authorities to adjust measures to their relevant context, the current setup may lead to ineffective and inefficient implementation. This can be shown using Greening, coupled payments and payment-redistribution of the current (2014-2020) CAP.

a) Greening: The inclusion of production-oriented options that do not substantially contribute contributing to biodiversity or sustainable land-use, and the flexibility for MSs to choose which options to list, resulted in a strong bias toward ineffective selection of options by MSs and farmers (for details see also Section S2)

b) Increasing distortive Coupled Payments: Allowing MSs the flexibility to increase the proportion of Coupled Payments has led to a rapid increase from 6 to 15% of Pillar 1 budgets, after a long period of systematic, designed process of shifting from coupled to decoupled payments (i.e., phasing-out). This case demonstrates how flexibility was used to allocate large proportions of CAP funds to supports to specific sectors, with poor justification and little provision of public goods. It furthermore undermines equality and the principle of the common markets (*154*), since it affects farmers' decisions and trade-flow within the EU (*162, 163*). Additionally, flexibility for MSs to shift budgets toward sectoral support can lead to a '*subsidy race to the bottom*', where MSs compete for the highest payments for their farming sectors.

c) Ineffective redistribution of Direct Payments: The originally proposal for a progressive reduction of DPs to decrease the bias between DP recipients was changed in favour of a choice option. MSs could reduce payments above 150k €/farm by at least 5% (*degressivity*) or introduce a redistributive payment for the first hectares for up to 30% of Pillar 1 (*first hectare payments*). The payment can be granted for up to the first 30 hectares or the national average farm size. The application of an upper limit (*capping*) was voluntary (*54*). Overall, redistributive payments *(first hectares)* accounted for about 1.609 Mio. EUR in the 2017-budget (*6*) (2.8% of 2017 CAP-budget). In contrast, the amounts redistributed by degressivity, were smaller. According to the EC, *reduction* and *capping* contribute only 98 Mio. EUR. Within this second type of redistribution, Hungary had the largest share of payments subject to redistribution with about 6.6%, followed by Bulgaria with 1.4%, and most MSs had with shares below 1% (*65*).

The decisions of the MSs can be summarized into the following three redistribution models:

a) **Loose Degressivity:** most MSs used a minimal reduction of payments between 5% and 50% (BE-FL, BG, CZ, DK, EE, ES, IT, CY, LV, LU, MT, NL, PT, SI, SK, FI, SE, UK-EN, UK-SC, UK-W).

b) **Strict Capping:** in most cases combined with some kind of degressivity (BE-FL, IE, EL, HU, AT).

c) **First Hectares:** mainly applied by mostly larger MSs (BE-W, BG, DE, FR, HR, LT, PL, RO, UK-WA).

d) **Mixed Models:** three countries MSc were included in a *Mixed models* group since they have different options applied (BE, UK, IT).

We calculated the Table S5.1 shows the GINI-coefficient for DP prior to the 2013 reform and after the introduction of redistributive payments in 2014/15. The GINI-coefficient of inequity to allowed to explore how the redistributive measures taken by MSs after 2014/15 affected the inequality of DP distribution (i.e. higher GINI-coefficient values indicate high inequity between farm sizes, whereas lower values indicate a rather even distribution).

Table S5.1: Change of GINI-Coefficient as a result of different options of redistributive payments

	First Hectares	Strict Capping	Loose Degressivity	Mixed Regimes
2015	**0.7934**	**0.6781**	**0.7670**	**0.7954**
2017	**0.7794**	**0.6540**	**0.7533**	**0.7494**
Change 2015-2017	**- 0.0140**	**- 0.0242**	**- 0.0137**	**- 0.0460**

Source: own calculations, data from (*98*).

The effect of redistribution expressed by the changes from 2015-2017 (Table S5.1) shows 'Strict Capping' to have the largest redistributive impact (-0.024). Most MSs have chosen the 'Loose Degressivity' -option, which results in a lower redistributive effect (-0.014). The most effective option ('Strict Capping') was chosen by those MSs with a lower level of inequality in the first place. Thus, overall, MSs with low levels of inequality have chosen rather effective measures that affected only few farms, whereas MSs with high inequality have chosen rather ineffective redistributive options, whereas any other option would have affected more farms.

These results suggest that flexible elements within the redistributive options were mostly used by governments to rather minimize the redistributive effect and thus failed failing to reach the objective of a more equitable distribution of DP.

Statement: Higher flexibility is granted to MSs without setting EU-level targets, target-oriented indicators, improved monitoring guidelines, or improved incentives and sanctions to ensure that desired impacts are achieved

Setting **targets** is envisaged to be conducted within MSs and linked to Strategic Plans. Yet it is not clear how these will be evaluated and approved by the Commission, and what criteria, incentives and sanctions could be used to ensure that targets and associated indicators are S.M.A.R.T. There is also no clarity on how policy management will be employed, i.e. which incentives, disincentives or sanction would be implemented if certain targets (e.g. reduce "*income disparities (I.2)"* or "*farm income variability (I.3)*") are not achieved between 2021-2027.

Experience from RDP has shown that, although RDPs contain a number of elements of good governance, 'policy management' (i.e. reaction to poor performance) remains weak (*176*). We can therefore anticipate that the new delivery model based on the MS level, now implementing some of the same approaches on Pillar 1, will be associated with similar challenges. However, it is not clear how the new delivery model addresses the need for clear instruments for policy management (i.e. revisions of plans, controls and clear sanctions in cases of non-delivery).

Examples of aspects demonstrating the potential weakness of the proposed implementation model in terms of sanctions and incentives are:

- **A lack of requirement** for justification or approval processes (especially after year 1 of the next CAP), allowing MSs to perform budget shifts with little transparency or potential for a public debate or evaluation. This can end in further eroding Pillar 2 and particularly AECM budgets.
- A shift of focus from greening to Cross Compliance and the "**new conditionality**" (a reduction of potential sanctions from 30 to 5%).
- This might lead MSs to set less ambitious targets to ensure meeting them later to obtain the performance bonus (*22*).
- No clear definition of a **review and revision process** of strategic plans and/or other reports. Officials of the Commission have also announced that the "specific context of a country" will be considered. This, however, makes the process even more unclear and open to political bargain.
- No **clear sanctions** for MSs if targets within strategic plans are not reached.
- A "**performance bonus**" proposed to MSs if reaching environmental targets (Article 123, 2018/0216). To this end, 5% of budget payments will be paid out based on MSs reaching 90% of environmental and climate targets which are evaluated using result indicators (*22*). However, it does not incentivize ambitious targets, and is not related to an increase in budget (Article 92).

Statement: Most 'output' indicators and many of the 'result' indicators ((2), Annex I) are not proxies of aspired outcomes but merely depict the area or number of farms under certain commitments

Annex I of the proposed CAP defines three types of indicators - **Output**, **Result**, and **Impact** indicators. It is neither clear how the indicators' list was developed, nor how it would be updated and improved. Still the list does not take up the existing knowledge offered by the literature for the development of effective and efficient indicators.

First, while some indicators clearly relate to targets (e.g. R18-22 and I13-17 for soil, air quality and water and nutrients), many **do not clearly adhere to the definition they are being assigned to.** Among the Results indicators, a large number delineates hectares or number of farms under certain commitments. These, per se, are merely descriptive, administrative registries. They do not capture the quality of such commitments, nor can be linked to a specific anticipated result or impact. **The lack of clear distinction between output, result and impact indicators** can also be seen in terms of Impact indicators. For instance, I.1 (*"Share of CAP budget for knowledge sharing and* innovation") merely evaluates expenditures (i.e., Outputs), and most indicators do not relate to a clear trend which would be required if a *result* is to be anticipated, or a baseline against which improvements would be measured (*88*).

Statement: Indicators for land-use changes, ecosystem services, specific GHG emission sources and HNVf are absent or insufficient

- **Land-use:** Despite well-established impacts of land-use change on both environmental and socioeconomic performance, and despite much investment in registry systems through IACS / FADN, no indicator is listed that utilises these data.
- **Biodiversity, ecosystem services and HNV farming systems:** Despite breadth of ecological literature focusing on indicators for good ecological conditions, birds comprise the only direct indicators for biodiversity. The extent of HNV areas, listed as an indicator in the current CAP (I 09), has been removed and no longer appears in the proposed CAP. No indicators are proposed for ecosystem services such as pollination, pests (and its natural controls), risk-prevention and mitigation (e.g. fire risks, floods), cultural services that affect rural vitality or landscape features that offer aesthetic values and contribute to economic benefits. Established indicators, such as the conservation status within the Habitats Directive, permanent-pasture quality or the butterfly grassland indicator (*90*) are not taken up. There are also no indicators for pesticide leakage into groundwater and surface waters.
- **Climate indicators:** R.14 (Carbon storage in soils and biomass) offers an improvement by measuring the "share of agricultural land under commitments to reduce emissions, maintaining and/or enhancing carbon storage (permanent grassland, agricultural land in peatland, forest, etc.)". However, there are no indicators referring to specific GHG emissions from agricultural sources. Instead, R.13 looks at "Share of livestock units under support to reduce GHG emissions and/or ammonia, including manure management" - but not at the number of livestock units per se being the source of these emissions.
- **Farm economy:** There is no indicator for overall farm-household economies and changes in their status, and no indicator on poverty risk or economic disparities among farmers. This is despite the availability of well-established indicators including "*Farm households with poverty risk*", which could be defined following the usual "*poverty at risk rate*" by Eurostat, which is a household with income lower than 60% of the median income (*129*), that could be incorporated. Instead, indicators such as R.6 merely measure redistribution to smaller farms, which is not an appropriate indicator for income since small farms (e.g. in the horticultural or pig sector) can have quite high revenues per Agricultural Working Unit (AWU).
- **Other sustainability dimensions:** Some objective are not reflected by indicators, e.g. for the supply and demand of "healthy, safe, nutritious and sustainable food", indicators relating to diets or overall consumption behaviour, or actions to inform consumers about impacts of over-consumption, obesity or healthy feeding. I.28 only measures the extent of "EU quality schemes" but focuses on production within them.
- **Global impacts due to European consumption:** There are no indicators to reflect the socio-economic and ecological impacts of European agricultural production on other countries and their abilities to meet the SDGs. Particularly the high ecological footprint of European consumption of agricultural goods and resulting competition on land-use in resource providing economies is not reflected by appropriate indicators.

- **Insufficient indicators to measure research and the integration of existing and new knowledge**: despite the explicit reference to EIP (European Innovation Partnership for agricultural knowledge and innovation) and AKIS, the way indicators relate to science and research does not support uptake of new knowledge (including the update of indicators). For example, the objective to *"Enhance market orientation and increase competitiveness, including greater focus on research, technology and digitalisation"* lacks any indicator regarding a greater focus on research, noting that science is far more than just the production of technology.
- **Indicators of good governance**, coherent with SDG 16 are missing to ensure transparency and inclusion. Examples can include the number of accessible documents and reports, data accessibility and positive access to data-requests (see recommendations).

Statement: Other Indicators are not justified

In some cases, proposed indicators do not have a clear relation to the objective they are supposed to link to, or can serve to undesirable outcomes. These can be considered as unjustifiable. Some examples:

I.12 adresses the "**Production of renewable energy from agriculture and forestry"**. An increase in renewable energy can contribute to the (further) expansion of monocultures, reduces food production and thereby externalizes EU's environmental footprint elsewhere.

R.8 accounts for the "***share of farmers benefiting from coupled support for improving competitiveness, sustainability or quality***". However, evidence suggests that coupled support actually reduces farm competitiveness. Additionally, during implementation by MSs, coupled support hardly relates to farm sustainability.

R.3: It is unclear how the "*Share of farmers benefiting from support to precision farming technology through CAP*" will contribute to improvements among farmers needing support in areas with production gaps, rather than enhance the success of farmers already employing intensive farming techniques. This indicator is therefore unjustified in fostering investments that may counteract efforts to reduce socioeconomic disparities.

Statement: The proposed implementation model risks hampering the added value of the CAP

MSs can independently prioritize options and targets in their strategic plans (*178*) and some scientists acknowledge the importance of such flexibility (e.g. (171)). However, with the absence of clear guidelines and undefined financial consequences of non-compliance, the proposed CAP does not seem to be guided by the principle of subsidiarity, but rather hands over responsibility for policy development and implementation to MSs (*176*). This can come at the cost of a lower EU added value.

The Subsidiarity principle proposes that policy-making should be undertaken by the lowest possible level that can produce effective outcomes. The economic theory of 'fiscal federalism' provides a theoretical and formal foundation on how a decentralised policy regime (given heterogeneous preferences in the regions and no economies of scale on the central level) can increase efficient public spending (*197*). This largely reflects the situation of the EU. Contrary arguments for a central solution are a) economies of scale in the provision of public goods; and b) homogeneous environmental, social and market-conditions across MSs. A decentral solution could enable national and regional governments to adjust policies to diverging social preferences and socio-ecological contexts. Thus, the appropriate degree of subsidiarity has to balance regulation and flexibility to maximize synergies, taking into account trade-offs between both.

While subsidiarity is proposed to be a guiding principle in the EU in general and the CAP in particular, the choice of flexibility elements is driven primarily by an effort of the EC to obtain the consent of MSs rather than by careful consideration considering and implementation implementing of subsidiarity. Consequently, flexibility often undermines the CAP's effectiveness and efficiency. Especially since 2005, the EC has repeatedly increased the use of flexible elements (Figure S5.1). In the case of the most recent 2013-CAP reform, the 'trilogue process' (i.e. the negotiation between European Commission, Council and Parliament) introduced flexible elements that were known to be ineffective were introduced and significantly weakened weakening the reform-outcomes (*178*), see also above).

Genesis of „flexible elements"

2003	**Different decoupling models** of direct payments, differently used within the EU member states (Fischler Reform 2003)
2008	**Regionalization of direct payments**, the option to maintain coupled payments within some specific agricultural sectors (Health Check 2008)
2013	**Some flexible elements** (Greening, coupled payments, flexible transfer between Pillars and options for redistributive payments) (Cioloș-Reform 2013)
2020	**Full flexibility within the strategic plans**: The proposed legal framework now proposes full flexibility in the national implementation, containing "strategic plans" with an agreement between EU and MSs on target-oriented implementation. (CAP-Reform post 2020)

Figure S5.1: A process of expanding flexible elements within the CAP since 2003

Source: own presentation.

The existing proposal of the CAP post 2020 does not reflect on which level policy should be decided. The proposed CAP shifts the decisions to the MS, yet without clarifying which policy element should be decided on the regional, national or European level and why. In this sense, the proposed flexibility is not linked to the subsidiarity principle and will not introduce the prescribed elements of 'fiscal federalism'.

Recommendation: The CAP post-2020 needs S.M.A.R.T (Specific, Measurable, Achievable, Relevant and Time-bound) targets and indicators for improved performance against clear baselines [and] there is a need to expand in situ monitoring

Open the indicators' list to inspection, sharpening and improvements. Both targets and indicators, at EU and MS level, should be **s**pecific, **m**easurable, **a**chievable, **r**easonable and **t**imed (S.M.A.R.T.), following Art. 30(3) Regulation (EU) 966/2012. Indicators should specifically address outputs, results and impacts and include all sustainability dimensions, including relevant agricultural GHG and global impacts of the CAP.

Ensure setting clear, measurable baselines (*179*). The idea of result-based payments is to ensure that farmers "maintain or improve" conditions (e.g. environmental indicators) against a real baseline (state of their own farm). Accordingly, the effectiveness and efficiency of the CAP should be assessed against real baselines rather than arbitrary EU-wide thresholds.

Develop adequate and cost-effective indicators to assess baseline conditions and monitoring. These should be aligned with international agreements (UNFCCC, CBD, WTO, etc.) and the SDGs. For instance, indicators of farm economy should reflect labour, living costs and total incomes of farm households. Indicators of climate change mitigation must cover the main sources of GHG emissions. The Farmland Bird Index, although valuable to indicate declining environmental conditions, needs to be complemented by other indicators for biodiversity (e.g. butterflies) and ecosystem services (e.g. pollination, pest control, erosion/flood/climate regulation, cultural services). There is also insufficient monitoring of the CAP's impacts on grassland types and quality, forest and forestry areas and management, crop rotation and crop diversity.

Expand in situ monitoring to assess biodiversity trends across broad spatio-temporal scales, and to investigate the effectiveness of targeted interventions and the impact of environmental drivers. Recent evaluations indicate that the costs are not impossible to bear: for instance, improving farmland biodiversity monitoring might only require 0.04%-2.48% of the CAP's budget (*180*). Monitoring should be done jointly with farmers and other citizens, to ensure delivery and to promote learning and adaptive management.

Promote citizen observatories for farmland biodiversity, facilitating empowerment, active 'learning by doing' (*181*), and enhancing engagement by farmers and the public. This is suggested as a complementary measure to stratified sampling by research organisations and/or agencies to support evidence-base and joint learning, knowledge exchange and adaptive management. Observatories need to be attractive and easy to use to foster active engagement and to visualise results in a timely fashion. While spatial aggregation of data is needed to protect privacy of farmers, observatories also serve the need for transparency ensuring that public money is well spent and leads to measurable results.

Recommendation: Monitoring and implementation processes should engage farmers, scientists, and citizens to better evaluate the impacts of interventions, to ensure delivery, and to promote societal inclusion, innovation, and adaptive management

Set up a clear evaluation and revision process: Implementation of MSs full flexibility will require a new system of policy management. This is already envisaged with the strategic plans (*156*). However, guidance using indicators to adjust, and update policies is lacking and instruments for policy management (i.e. revisions of plans) need to be provided.

Strategic plans need to address trade-offs: Clarifying how trade-offs between conflicting objectives should be addressed within strategic plans is essential. MSs are requested to perform a SWOT analysis (i.e. to assess Strengths, Weaknesses, Opportunities and Threats) to justify their Strategic Plan and implementation decisions. Clearer guidelines should be provided on how to address trade-offs emerging from these SWOT analyses to prevent MSs from favouring economic objectives while weakening environmental ones.

Clear sanctions in case of non-delivery: Beyond the system of policy management, proposed strategic plans lack functioning incentives and sanctions to the MSs for the case of non-delivery. Examples requiring improvements:

- **Performance bonus (Article 123):** Tie the performance bonus to MSs (Article 123) with observable, measurable improvements in environmental performance (against current baselines) based on well-established Impact Indicators including the status and trends of birds and butterflies, as well as “grasslands under good ecological status”.

- **Increase sanctions for environmental instruments:** these are necessary to ensure environmental safeguards. Sanctions need to be increased and implemented to support the former Greening requirements (now under CC, GAEC 4, 8, 9, 10).

- **Streamline and simplify controls of environmental instruments:** Controls must be streamlined between Pillar 1 (Greening, Eco-schemes) and Pillar 2 (AECM) (*182, 183*). Moreover, they must be simplified to ensure that administrative efforts and costs remain acceptable (*11*), without compromising the achievement for public goods and services (*3*). For instance, control mechanisms for AECM can be simplified and focused on the main content of AECM by withdrawing single paragraphs (as suggested by “EAFRD – RESET” (*184*), to reduce bureaucratic burdens (*155, 185*) and increase efficiency of AECM (*186*).

6. Supplementary Material 6: Improve the reform process

Statement: Previous reforms of the CAP have repeatedly been criticized for their lack of transparency

Previous CAP reforms have been criticised for being non-transparent and complex, with decisions being taken in Brussels, far removed from the attention of the media and, at least until the 1980s, without legally binding regulations. In the early years of the CAP, this led to the so-called 'restaurant table game' (*187*), an interpretation of CAP price-decisions within the EU Council of Ministers in which the ministers used the ‘EU menu’ to suit their own national agricultural sector. The costs were ultimately borne jointly by the six EU member states. Through the reform processes after 1992 and with an increased number of MSs from 12 in the 1980s to 28 by 2013, and through the Treaty of Lisbon (*12*), procedures became more transparent and formalized. In that sense, the Ciolos-reform of 2013 was the first reform after the treaty of Lisbon, using the ordinary decision mechanism (*188*).

Despite more transparent procedures and new decision rules, a high level of complexity within the CAP still maintains the problems of limited public participation and decisions that are partly still taken behind closed doors. Thus, the new flexibilities following the 2013 CAP-reform can be interpreted as ‘new restaurant menus’ for MSs, where the non-transparent decisions emerge again and encourage sector-specific rent-seeking lobbying behaviour. Particularly the final negotiation stage, or so-called trilogue-process which has taken place largely behind closed doors, offered the opportunity for agricultural ministers to shape the final policy formulation according to specific interests of their national farming sectors. It was at that stage that new, production-oriented options and so-called flexibilities were (re-)introduced despite lack of evidence that they benefits biodiversity. Uncertainty caused by complex objectives, and avoiding a clear coordination of biodiversity, climate, and other environmental concerns, have been found to weaken environmental performance in the current (2014-2020) CAP (*5, 30, 43, 102, 189-191*).

Statement: Budgetary decision pre-define reform processes against substantial changes

Budgetary decisions often predefine and restrict substantive and structural CAP-reforms (*118*). Based on EU legislation, the budgetary proposals for the Multiannual Financial Framework (MFF) are made by DG Budget and decided by the European Council (summit of the head of states) together with the consent by the EU Parliament (Article 312 TFEU). In the past, this process has repeatedly pre-determined the outcomes of attempted CAP reforms (*192, 193*), as demonstrated below.

1) The **Fischler-reform of 2003** intended to allocate budgets for sustainability targets and compensate potential losers. In October 2002, German Chancellor Schröder and French President Chirac decided to freeze total EU agricultural spending and maintain the relative

weight/relation between Pillar 1 and 2 (*189*). These decisions were motivated by fiscal policy and had the goal of creating discipline in spending, on the one hand, and keeping the increase in financial contributions from net contributors (especially Germany) within limits and manageable, on the other hand. However, the Schröder-Chirac compromise of 2002 meant that the substantial relative revaluation of Pillar 2, planned by Commissioner Franz Fischler, could no longer be implemented (*192, 193*).

2) As part of the **Health Check-reform of 2008**, the level of compulsory modulation was again limited to an additional 4%, while the EC under the leadership of Marianne Fischer-Boel introduced 30% voluntary modulation into Pillar 2.

3) Within the **Ciolos-reform 2013** (*189, 194*) and within the current reform toward the **CAP-post 2020**, shifts of budgets into Pillar 2 have been limited. This is specifically true within the multiannual financial framework proposed for 2021-2027, published in May 2018 (one month before the legal framework) and applying larger budget cuts on Pillar 2 (-28%), compared to Pillar 1 (-11%). The predetermined decision to maintain DP limits the range of options to decide, where need be, on potential structural changes such as giving more emphasis to rural areas and accordingly to Pillar 2.

Statement: Increasing diversity of CAP objectives has led to the coexistence of different discourses

Existing scientific studies explain incoherence in the CAP mainly with strong opposing interests and a missing specification of its many objectives, resulting in diffuse and ineffective policy designs (*192, 195, 196*). This promoted the increased activity of different lobby groups to push their specific priorities (*190, 195*).

Formerly, dominant political discourses were found to focused on neo-liberal objectives, such as market-liberalization, farm competitiveness, and productivity (*137*). In the 90s, this traditional ‘productivist discourse’, giving agriculture an exclusive position in society, was increasingly moving into a ‘post-productivism’ debate of alternative rural and societal needs calling for alternative forms of governance (*197, 198*). In response to international WTO negotiations, a neo-liberal discourse questioned the protective policies of European agricultural markets and called for market-liberalization and farm competitiveness (*137*), which was eventually used as a justification for decoupled payments and reduced market barriers. In parallel, a multifunctionality discourse introduced environmental and social considerations (e.g. support for remote or less productive areas), which have particularly been reflected in the justification of Pillar 2 instruments (*15, 137*).

Despite the emergence of those discourses and their visible influences, DP as the CAP’s broadest instrument is still representing a domination of the original **productivist discourse** (*15*). During the 2013 and the recent 2017/2018 CAP reform processes, we observe an increasing divergence of the discursive justification of the CAP and the prevailing institutional structure. Thus, despite the growing presence of multifunctional, public good and neo-liberal

discourses, the **increased complexity and plurality of discourses at the EU level enables MSs to cherry-pick elements** to sell EU-level outcomes to fit their respective national discourse. Thus and hence, '*serving the same CAP wine in different bottles'* (*14, 199*) reflects the fact that the co-existence of several discursive elements increases a regime's resilience to external critique as they can be taken up to legitimize different claims and positions. Indeed, a mapping and analysis of the CAP's implementation reports that competitiveness (as an element of the productivist discourse) was a main decisive point in the implementation of the CAP-reform (*200*).

Statement: The dominance of farmer lobby-groups in the CAP reform processes has watered down some originally ambitious measures (e.g. greening or redistribution)

The history of CAP reforms shows that agricultural lobby-groups have always been very successful in defending specific interests. The 'theory of collective action' proposes that small social interest groups with homogeneous interests are superior to larger groups with heterogeneous interests in the competition for political influence (*201, 202*), and can lead to more effective rent-seeking of small lobby groups with common interests (*187*). Complex, non-transparent decision-making structures further favours them pursuing their interests.

The view of the farmers associations is 'farm exceptionalism', where farming is a special sector and therefore deserves a specific policy including income support and an alignment of specific stakeholders and administrations interest (*203*). For example, greening as a multifunctional/ public goods discourse element was used to justify direct payments as the key productivist policy element (*15*). Concerns brought against stronger EFA regulations included the risks to food security due to reduced production area, threatened rural livelihoods, and increasing complexity (*30, 154, 204*). Notably, the first two arguments can be assigned to the traditional productivist discourse (*15*), and are not supported by evidence (for example (*41*)).

According to the initial CAP objectives of the Treaty of Rome (see table S2.1), analyses of past decision processes highlight the predominant influence of farmer lobby groups being a prototype of a '*neoclassical reform model*' (*203*). The example of greening shows how during the last CAP reform, particularly during the trilogue negotiations, regulations were watered down. Both EU Commission and Parliament were dominated by farm interests softening greening regulations by adding more exemptions, light green measures and excluding potential incentives from double funding (*188*). Notably, COMAGRI (the Parliament's agricultural committee) has been said to support farmers' interests as 31% of its members had either owned a farm or been member of a farmers' association (*205*). While an increasing adoption of environmental targets has been used to legitimize the CAP's structure, the limited influence of environmental actors is a credible explanation for the weak performance of environmental measures (*5*).

Statement: the reform process lacks structure and transparency

The first stage of the CAP reform, including harvesting inputs from the public and evaluating the current CAP, has been completed with the publication of the CAP proposal in June 2018. The second stage, where amendments are taken and negotiated, is currently ongoing. A close examination of the first stage of the reform process reveals a more inclusive than previous reforms, but still lacking structure and transparency.

Key issues relate to the **sequential order of reform-elements** in the preparation of the CAP proposal, and an unclear or even biased process in taking and processing inputs toward the proposed CAP-reform consisting of the proposed MFF 2021-2027 (May 2018) and the proposed legislative proposal (June 2018).

- First, despite calls by several organizations in 2016 to start the reform with a reliable evaluation process, or a so-called “fitness check” (*206*), the EC has repeatedly declined to open such an evaluation (*16*). Such evaluation has eventually been launched in autumn 2018 and conducted over 2019, many months after the CAP proposal has been published and negotiated in the Council and the EU parliament.
- Secondly, the new budget in the Multiannual Financial Framework (MFF) 2021-2027 has been proposed in May 2018, prior to the publication of the CAP proposal in June 2018, and thus, as in previous reforms, biasing the process by predetermining the range of options for potential improvements. That budgetary decisions have pre-empted the reform process of 2017 is hinted in the introduction to the CAP proposal of June 2018: "*the Commission consulted widely on the simplification and modernisation of the CAP to maximise its contribution to the Commission's ten priorities and to the Sustainable Development Goals (SDGs). This focused on specific policy priorities for the future without prejudice to the financial allocations for the CAP in the next MFF.*” (EC 2018, p.2).

The process of public engagement poses questions as well on its design and processing of inputs. We here examine: 1) the public consultation; 2) workshops and stakeholder conference; 3) the communication document published November 2017, 4) the Impact Assessment; and 5) the way in in which inputs from all were used for developing the proposed CAP.

1. Public Consultation Process

The CAP reform started early in 2017 with an **Online Consultation** by the EC to obtain public opinion on how to modernise and simplify the CAP (*207*). The consultation ran for 12 weeks (February-May 2017) and received 322,916 responses. It gave farmers, citizens, organisations and other interested parties the chance to have their say on the future of the CAP (*208*). However, we note that:

- Respondents were a small (<0.01%), non-random subset of EU’s population (45.6% from Germany, and 6.7% from new MSs) who actively chose to participate after being invited, unlike e.g. the Eurobarometer where people are randomly selected and approached.

- Numerous individuals and organizations argued that some questions were biased. Such closed-ended questions were left unanswered by most recipients. However, analyses did not account for the proportions of respondents choosing not to answer (*207*).
- We identified a range of discrepancies between the reported results and those seen in the report figures. However, despite requests, raw results were not made available to the public, thus being non-transparent and not allowing an independent re-analysis.

Altogether, it is unclear how the outcomes of the public consultation fed the proposed CAP.

2. Stakeholder workshops and conference

In preparation of the reform, the Commission organized a series of workshops as well as a Stakeholder Conference ("CAP: Have your say!") in July 2017. However, the workshops to inform the reform and to prepare the Impact Assessment were organized internally by DG Agriculture and it is not clear how participants were selected. Key organizations, such as environmental NGOs and scientific organizations, were not invited to some of these workshops and the conference, while farmer organizations were over-represented especially at the July conference. No protocol of the conference was made public, and it remains unclear if conclusions from it were used for decision-making.

3. EU Commissioner statements

The challenge of producing a coherent CAP is shaped by existing power constellations and discursive framing. These can also be derived from speeches delivered by the EU Commissioner Phil Hogan. For example: "*Indeed, close consultation with both COPA and COGECA has been a constant feature of the process in preparing and drafting this proposal*" (*24*). Another example: "…*I have fought tooth and nail to ensure that Direct Payments remained the top priority in the MFF discussions*" (*209*). These examples and others, as well as the choice to conduct an "*evolution rather than a revolution*" (*210*) seems to reflect a strong impact of lobby organizations as well as reluctance to change.

4. Communication Document

On 29. Nov. 2017 the EC released the initial document **"The future of food and farming"** to indicate the proposed direction of the next CAP (*178*).

The European Court of Auditors (*19*) examined the document and concluded that it is not ambitious enough. Authors of this paper analysed the Communication Document as well (see www.idiv.de/cap-fitness-check), identifying some potential improvements but also listing ten major gaps and weaknesses of the Communication Document. We received no response from the Commission, and the proposed CAP of 2018 has largely retained the same elements. It is therefore unclear if, and how, inputs from various organizations were used to develop the proposed CAP.

5. **Partial Impact Assessment**

As in previous CAP reforms, the Commission conducted an Impact Assessment (IA). However, the processes underlying this impact assessment were neither transparent nor inclusive. There are several issues with the impartiality of the IA in supporting an objective evaluation, rather than a predetermined reform path:

- We are not aware of options for the public or selected organizations to contribute to the preparation of the impact assessment (IA), or assess the document and comment on it prior to its final release at the same date as the proposed Legal Framework. Notably, outcomes from an independent literature review, the "fitness check" outcomes of a comprehensive independent literature review were largely ignored (*43*), taking only the SDG outcomes of the study ((*2*) Annex 5, p. 73). Other important documents were ignored as well (e.g. (*123*)).
- In the introduction to the proposed CAP (legal framework) it is explicitly mentioned that an early version of the IA was declined by the Regulatory Scrutiny Board: "*RSB has initially issued a negative opinion. While appreciating the ambition to modernise and simplify the CAP and the in-depth analysis of different scenarios that usefully highlight the trade-offs between the policy objectives, the Board considered that the report should better explain the rationale, feasibility and functioning of the proposed new delivery model*"(*2*). This means that the IA was (re)designed to support the delivery model rather than to guide it.
- Results of the JRC's modelling that were used to produce the IA were not made public.

Altogether, it is unclear how different sources of evidence, and types of contribution, were used to develop the proposed CAP.

Statement: The choice to maintain the CAP's structure and expand DP ignores compelling evidence, public opinion, and published feedbacks on the initial CAP proposal, thus showing strong reluctance to change

In the current CAP proposal, we observe an even stronger divergence between justification narrative and the reality posed by actual instruments and budgets. On the one hand, the Commission strongly points to sustainability as central societal challenge, emphasizing the need for biodiversity conservation and climate mitigation as important public goods. This is seemingly reflected by conditioning all direct payments to CC, following the WTO's objective to phase out all agricultural subsidies that do not directly serve sustainability criteria. On the other hand, the absence of specific sustainability targets and instruments (e.g. for effectively reducing carbon emissions and the international footprint) and the weak enforcement procedures connected to CC, lead to actual weakening of current instruments while justifying the persistence of DPs and even expanding their extent.

Overall, the choice to maintain the CAP's structure and expand the relative share of DP, as well as the listing of 40% of payments as 'climate friendly', seems to follow a predetermined

path which conflicts the majority of public inputs (Fig. S6.1, (*1*)), compelling evidence (*7, 9, 11, 16*), and published responses on the initial CAP proposal (e.g. (*19*)).

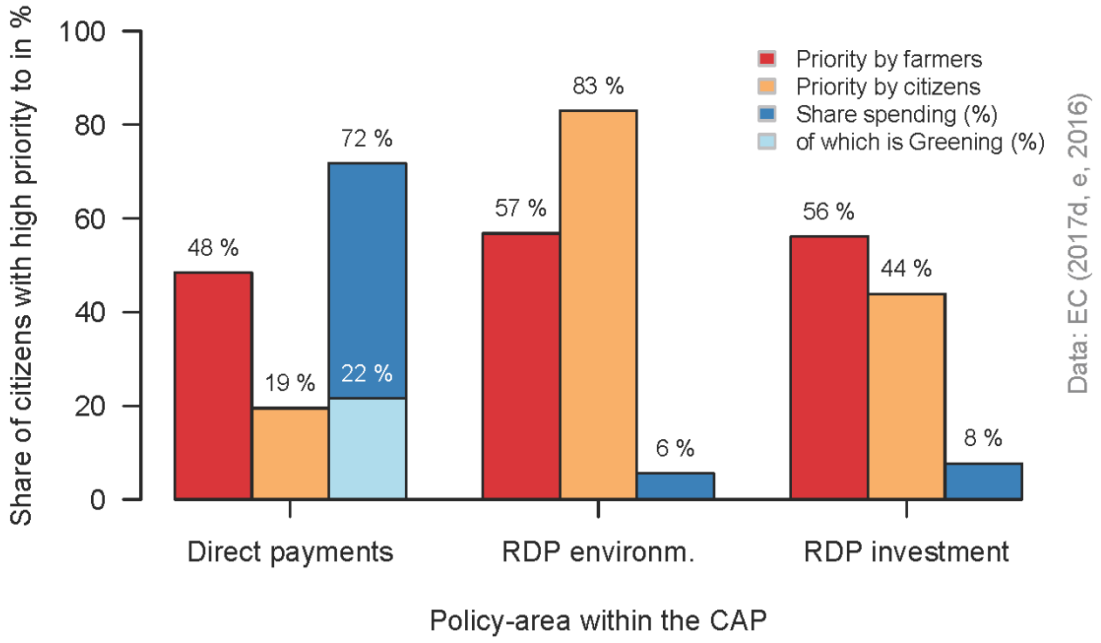


Figure S6.1: ***The 2017 Public Consultation indicates that both farmers and the general public perceive Pillar 2 payments for public goods as the best instrument to address current challenges, whereas most CAP funding goes to DP. This mismatch will increase based on the proposed CAP budget.***
Source: EC (2017d,e, 2016)

Recommendation: The CAP's design and implementation, currently governed by agricultural committees, ministries and agencies needs to fully integrate their environmental counterparts to reflect on the multi-functionality of agricultural and rural areas, and the range of affected stakeholders

While some level of integration has already taken place, i.e. Environmental Committees at the Parliament has some influence on decisions by receiving an "associated committee" status (under article 54 of the EP rules), decisions are still largely taken by agricultural committees only. A real integration, however, can only be achieved if article 55 is applied ("joint committee procedure" (*211*)). That would entail that decisions are taken jointly as already taking place for climate and energy topics.

Recommendation: Robust and transparent policy design should be built around existing knowledge and societal preferences, ensuring a balanced representation of all relevant stakeholders

Much would be gained if the EU uses a transparent, proactive, integrated and participatory decision-making process. Policy-design processes should integrate sectors and involve political, business, scientific and other actors in a transdisciplinary learning process. Integration of diverse knowledge types can be achieved through open participatory processes, systematic evaluation and synthesis of evidence. To reach a process which is truly inclusive and evidence-based, the EU needs to actively seek to bring together scientists from multiple disciplines, farmers (representing a diverse, heterogeneous community) and all key – stakeholders (e.g. less heard/included) particularly from new MSs.

MSs should further support vertical integration (i.e. participation of local stakeholders, support of bottom up initiatives), to achieve a much-missing process of knowledge transfer, learning, and scaling up of local successes. Particularly, supporting community-based initiatives, and incentivizing and empowering monitoring and adaptive management, are essential. Offering further platforms and opportunities for horizontal exchanges and effective knowledge-transfer, also on the CAP's design, seem essential given the heterogeneity of stakeholders and the complexity which is inherent to the multi-functionality of agricultural lands.

The scientific community can help informing policy design by concrete recommendations and progressing indicators and monitoring. Opportunities emerge in expanding the use (and transparency) of registration tools such as the EU's Integrated Administration and Control System (IACS) and respective EU's Land Parcel Identification System (LPIS). Additionally, citizen science e.g. through farmer-led observatories offers both opportunities for data-gathering and participatory measure design and implementation.

Existing data and documentation should be made available for the public for evaluation and comments prior to approval processes. A transparent reporting of how inputs were used (or not) should be implemented.

Recommendation: Strengthen the science-policy interface and use scientific knowledge

Scientific knowledge and on-the-ground experience are essential and should be much better incorporated not only into implementation but also into CAP design and revision itself – both at EU level and in MSs. The next CAP reform should strive to make good use of existing scientific evidence. Given the wealth of knowledge and evidence of the impact of CAP measures, there are already sufficient recommendations for good practices and for enhancing policy coherence and efficiency, as well as suggestions on how to mitigate conservation-production conflicts. Better inclusion of science has the potential to inform, guide and accompany the process as 'honest broker' and to facilitate the route to optimal or at least to better solutions and to identify "least cost paths" or even win-win options.

To strengthen the inclusion of scientists in a science-policy interface, it is important to include scientists in monitoring and evaluation processes of the CAP and its implementation (see e.g. Article 94 & 111).

Recommendation: Science should fill knowledge gaps

Identifying and addressing policy-relevant knowledge gaps is essential for the uptake of the outcomes. Examples of important knowledge gaps include:

(i) indirect impacts of DP on biodiversity and ecosystem services;

(ii) CAP impacts on consumer behaviour and associated global footprint;

(iii) a better assessment of CAP contributions to SDGs, including e.g. SGD 5 (e.g. gender equity) and SDG 11 (Make cities and human settlements inclusive, safe, resilient and sustainable).

(iv) assessing the joint impacts of all CAP's instruments (and related policies) using a social-ecological systems' perspective. Structured inter- and transdisciplinary research processes should integrate scientific and local knowledge to develop solutions to sustainability challenges and exposing and addressing trade-offs.

(v) examining the scientific, political and societal paradigms that feed political discourses (such as the call for more food, feed and fuel production), as well as the social processes impeding policy implementation.

Scientists should ensure that research questions are relevant to farmers and decision makers, and help demonstrating and promoting innovative potentials of local initiatives and horizontal exchanges. In addition, up-to-date data of CAP related issues should be easily accessible to scientists in order to conduct most relevant analyses on the performance of the current CAP. Finally, scientists should learn more about policy-design and revision processes to be able to ensure that evidence is provided in order to offer better solutions for conflicts or help reach goals and ambitions.

7. Supplementary Material 7: Acknowledgements

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8. Supplementary Material 8. Raw outcomes of SDG evaluation of relevance and performance (separate Excel file)

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