Multi-faceted returns on investment for EU agricultural research and innovation

What are the economic and societal benefits of investing in agricultural research and innovation?

This paper examines the returns on investment in EU agricultural Research & Innovation (R&I), outlining the multi-faceted societal, economic, and environmental benefits as well as the current limitations of measuring returns.

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SUMMARY: THE IMPACT OF R&I INVESTMENT ON SUSTAINABLE FOOD SYSTEMS

Agricultural research investments should allow the EU to speed up the transition of its farming sector into sustainable agriculture, ensuring food security and reducing its climate and environmental footprint. Ongoing discussions on the future of agriculture have widely recognised that digitalisation is one important aspect to work on, as well as the incorporation of new technological tools in general.

It would, however, be a mistake to over-concentrate R&I investments on top-down technology-driven solutions. Although past evolution had been guided almost exclusively by off-farm scientific progress, in particular in crop yields, future developments should encompass wider societal challenges to measure successes.

In the accelerated globally changing context that we are experiencing, economic metrics are not sufficient for calibrating R&I investment in scale or direction. We need a multi-dimensioned framework build on sustainability indicators to guide public investments to deliver their best. Pressing challenges make agricultural R&I now more than ever a priority to orientate sustainable food systems to the often-conflicting challenges of food security and preservation of natural resources.

Experience gained over recent years has shown without ambiguity that farmers involvement in research agenda settings and implementation allows for a more rapid dissemination of research findings and innovative solutions. It has also been demonstrated that multidisciplinary approaches generate better, future-proof results with positive economic impacts. The multiplication of operational groups on the model of the EIP-AGRI, networking, living labs and experimental farms are strong assets for the EU agriculture transition and for making swifter the returns on agricultural R&I investments.

Transition pathways should align agricultural objectives with the big targets of climate neutrality and biodiversity protection set by the European Green Deal, as well as with the 17 Sustainable Development Goals. One crucial precondition is that sufficient public funding is reserved for agricultural research in the coming years, whereas models show that every Euro spent in R&I will return 10 to 11 Euros to the economy.

R&I should also show how will we walk the talk of sustainable farming in the EU. For example, the Horizon Europe Mission on 'Soil Health and Food' could realise a greater impact by having the stated ambition to turn EU soils into carbon sinks. Furthermore, several sensitive issues require sustainable solutions by EU agricultural research, such as pesticides use reduction, raising antimicrobial resistance, genome editing and its potential use for breeding.

EU RESEARCH POLICY AND RETURN ON INVESTMENT: MEASUREMENT INDICATORS AND THEIR LIMITATIONS

Agricultural investment

Time and money invested in agricultural research bring indisputable benefits to society. Confronted with the ever more pressing challenges facing our planet, including food security, should agricultural research intensify or build on existing cumulated knowledge for advancing future-proof technologies in the farming sector? In other terms what will be the returns on investment in agricultural research? This is the question this paper examines in the EU context with a view to providing advice to policymakers.

The next section provides a brief overview of the EU agricultural research landscape before looking at the traditional measurement indicators of

economic return on investment and their limitations. The following chapters will look at the multi-faceted returns of the future EU R&I programme, Horizon Europe, and explore ideas to leverage even higher its return on investment.

EU agricultural research landscape

The European Union (EU) sets a direction for agricultural research and innovation through two policies: the framework programmes (FP) financing research for a seven-year period, the most recent being Horizon 2020; and the Common Agricultural Policy (CAP), in particular its second pillar devoted to Rural Development. Budgets allocated in past Multiannual Financial Frameworks (MFF) have registered constant increases along the successive R&I FPs while attempts to reduce CAP spending imposed a downward trend on agricultural expenditure from the EU budget and a gradual redistribution of farm support between the EU Member States.

The agreement on the future EU budget, including the MFF for the 2021-2027 period, together with the Next Generation EU programmes, takes a great step to deeper EU integration, but also puts a break on past trends. For the first time, the R&I budget does not increase. Despite a €100 bn Commission proposal and calls from the Parliament to raise it at €120 bn, the agreement reached in July 2020 by the heads of state and government set the R&I allocation for Horizon Europe at €80.9 bn, roughly the same envelope as the previous Horizon 2020 programme.

Conversely, the CAP still absorbs a third of the MFF, as the envelope for direct payments to farmers (pillar 1) is preserved, but its rural development pillar (in which innovation and research expenditure sits - pillar 2) is significantly reduced. This leads to questions over the transformative role of this branch of the EU agricultural policy, notably the investments for innovative approaches to farming. This also poses the question whether the funding for agricultural research will suffice, while high economic returns from R&I investment are expected from all parties, in a context of pressing calls for the swift transformation of the farm sector and food systems.[1] [2]

From a purely economic perspective, the share of primary agriculture, forestry and fish production in total GDP is low, at about 1.4% in the EU on average, with slightly higher figures in the Eastern part of Europe and lower in the West. Agricultural research, however, has always been a subject of attention from governments either for strategic reasons of food sovereignty or

[1] IEEP (2019): https://ieep.eu/news/agriculture-and-land-management/agricultural-randi/cut-proposals-to-eu-budget-and-horizon-europe-risk-leaving-urgently-needed-ambition-on-paper

[2] IEEP (2020): https://ieep.eu/news/agriculture-and-land-management/agricultural-randi/achieving-food-system-resilience-as-part-of-the-eu-s-recovery-plans

economic considerations: competitiveness gains in the primary sector allow the rest of the economy to grow.

The return on investment is high. From a public goods perspective, each euro of the EU budget invested in R&I brings large GDP gains. Several macroeconomic models used by the European Commission have shown that for Horizon Europe, the next generation of FP, additional GDP brought by the R&I on average over 25 years could generate a return ranging from €10 to €11 of GDP gains over the same period for each €1 spent[3]. Although models envision the economy as a whole and do not give sectorial indications, the same assumption could apply to agriculture, given that agricultural research is part of European R&I programs, obey the same rules and attracts special political attention.

Research funded by the EU budget represents about 10% of all publicly funded research in the EU in all domains, agriculture included. Although this share seems modest at first glance, it has a major steering role impact in the EU scientific powerhouse. Since its first FP in 1984, the EU policy for research, development and innovation supported public goods with a high European added value, meaning achievements which would have never been possible by separated, uncoordinated national R&D policies. As shown in the impact assessment of the proposal for Horizon Europe, through EU-wide competition for excellence, EU investments support the training and mobility of scientists, create transnational and multidisciplinary collaboration, leverage additional investment from the public and private sectors, build the scientific evidence necessary for effective EU policies, and structure national R&I systems (European Commission, 2018). This conclusion equally applies to the sectorial R&I for agriculture.

As from 2014, agricultural research was singled out in the EU's research policy. The then Commissioner for Agriculture and Rural Development, Dacian Cioloș, obtained that a specific portion of the research budget will be entrusted to the DG in charge of agriculture and rural development, with a view to accelerating research findings dissemination among the farming communities and to better respond to farmers' needs.

Within Horizon 2020 – the European R&I programme for the period 2014-2020 – among the seven Societal Challenges (SC) [4] of the second pillar of the program, some €3.8 bn was attributed to SC 2 (Box 1), covering agriculture,

[3] European Commission (2018) Impact assessment of Horizon Europe. Staff working document, annex 5: Macro-modelling: https://ec.europa.eu/info/sites/info/files/swd_2018_307_f1_impact_assesment_en_v6_p2_977548.pdf.

[4] Societal Challenges address major concerns of the European citizens through collaborative research calls, comprised of topics organised in Work Programmes approved by the Commission. Horizon 2020 identifies in its second pillar 7 priority challenges: 1) Health, demographic change and wellbeing, 2) Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy, 3) Secure, clean and efficient energy, 4) Smart, green and integrated transport, 5) Climate action, environment, resource efficiency and raw materials, 6) Europe in a changing world - inclusive, innovative and reflective societies, 7) Secure societies - protecting freedom and security of Europe and its citizens.

food, bioeconomy and maritime research. It is jointly managed by two DGs of the Commission, DG RTD and DG AGRI, the latter being entrusted with on-farm R&I.

Box 1: Societal challenge 2 in Horizon 2020

Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy

Broad lines of activities:

- Sustainable agriculture and forestry
- Sustainable and competitive agri-food sector for a safe and healthy diet
- Unlocking the potential of aquatic living resources
- Sustainable and competitive bio-based industries and supporting the development of a European bioeconomy*
- Cross-cutting marine and maritime research

The assets and weaknesses of EU R&I are well known in the policy sphere. Amongst the assets across disciplines, the R&I FPs boost collaborative research, enable a European research community to emerge, are highly attractive as oversubscription and subsequent low success rates of applications demonstrate it[5] and their international dimension is undisputed, with a range of associated research country partners far beyond the limits of the EU. A notable weakness is the poor dissemination of results, a persistent East-West divide and long waiting periods before market uptake and upscaling can start.

For agricultural research, a supplementary asset is provided by the dynamics of a consultative organ, the Standing Committee on Agricultural Research (SCAR)[6]. Not only SCAR delivers advice on agricultural and wider R&I to the Commission and the Member States, but also acts as a major catalyst for the coordination of national research programs. This is a valuable asset for converging forces across Europe and make the best synergetic use of the public

[5] For the first three years of Horizon 2020, there were 102,076 eligible applications of which 45 % were assessed of high quality, yet only 11,108 grants could be signed within the assigned budgetary envelope. This a 11.6 % "success rate" ratio (cf. Mid-term evaluation report, European Commission (2017): https://ec.europa.eu/info/publications/interim-evaluation-horizon-2020_en).

[6] Initially one of the many consultative committees established by the CAP, nowadays, a modernized SCAR is made up of representatives from 37 different countries, the members being ministries or other public organisations such as research councils from EU Member States, with Candidate and Associated Countries as observers. https://scar-europe.org/index.php/home-scar/organisation

funds devoted to agricultural research. Several shaping papers get published by the SCAR to inform the use of R&I funds (Box 2).

Box 2: SCAR activities

- Foresight
- Strategic Working Groups:
  - ARCH (Agricultural Research for greater impact on global Challenges)
  - AKIS (Agricultural Knowledge and Information Systems)
  - Bioeconomy
  - FISH (aquaculture and fisheries research)
  - Food Systems
  - Forest
- Collaborative Working Groups:
  - Sustainable animal production
  - Animal health and welfare research

IS IT WORTH INVESTING IN AGRICULTURAL R&I?

During the second half of the 20th century the world population doubled, and global food security was achieved thanks in part to the role of research, which allowed remarkable increases in yields per hectare. It was the so-called "Green Revolution", combining new selected varieties, like dwarf wheat, to external factors of production: machinery, irrigation, fertilizers and pest control products. Negative consequences on the environment, climate and health appeared later, with agriculture and food systems now being central to planetary boundaries overshoots. Intensive farming techniques cause biodiversity loss, water overuse and nutrient depletion. Food production accounts for 26% of the GHG emissions in the world[7] while 30 % of food is wasted along the supply chain.

The urgent need to redirect agriculture and food systems to sustainability within the next ten years is widely recognized. In an open letter, the Club of Rome calls leaders to "*rethink how we use land and transform our food systems*" by "*investing in sustainable food systems and regenerative agriculture*".[8] Finding practical solutions to both addressing and reversing the impact of

[7] https://ourworldindata.org/food-ghg-emissions

[8] Club of Rome (2020) https://clubofrome.org/impact-hubs/climate-emergency/open-letter-to-global-leaders-a-healthy-planet-for-healthy-people/?fbclid=IwAR14i9a8U8AJ2zXpKj8WgLCYLR7omSIkdUu3hRlsxKKSdppY7zPY3TwaJkU

agriculture and forestry on climate and the environment whilst ensuring long term productivity should be a core goal of R&I priorities in this area.[9]

Yet investments in agricultural research slowed down in the '90s, while they still represented an already modest part of the total public and private R&D in the world. As shown by Pardey et al.[10] private research investments are limited – estimated at roughly one third to 40% – and occur mostly (90%) in developed countries. Publicly funded agricultural research remains the principal source of innovations for farmers in the developing world. They may also rely on R&I spillovers, generally subject to the adaptation of knowledge and technology to their local economic and agroecological conditions.

This places more responsibility on rich countries, the only ones able to increase their R&I intensity, among them notably the EU. Observed trends in agricultural R&I spending show that low-income countries, most of them in sub-Saharan Africa, have made little headway, while agricultural R&I spending in middle-income countries such as Brazil, India and China has grown substantially.

Economists have developed metrics to try and capture the future value of R&I spending results, taking account of flows of costs and benefits and the inevitable time lag in years before research produces new usable and commercially viable technologies. Pardey et al.[11] refer to the benefit-cost ratio (BCR) and the Internal rate of return (IRR). BCR is the ratio obtained by dividing the present value of the benefits by the associated stream of research costs. The IRR is the computed discount rate that equates the present value of the benefits and the present value of the costs.

Both measures pose problems of data, working hypothesis and interpretation but nevertheless allow for comparability and one can draw certain conclusions. In particular, the authors consider that "*society has persistently underinvested in public agricultural R&D*" and "*if this underinvestment continues and the supply of important agricultural staples fails to keep pace with the growth in aggregate demand, increasing food prices will further stress the world's most vulnerable populations*".

Economic metrics, such as farm incomes or export value or more refined indicators like BCR and IRR, are not sufficient to judge the necessity to invest in agricultural R&I and to which degree of intensity. An accelerated planetary changing context requires a wider vision, beyond GDP, that should try and measure how many degrees of sustainability will be gained thanks to new

[9] IEEP (2019) : https://ieep.eu/news/agriculture-and-land-management/agricultural-randi/position-paper-co-designing-horizon-europe-towards-greater-sustainability

[10] Pardey et. al (2014) Investments in and the Economic Returns to Agricultural and Food R&D Worldwide. Encyclopedia of Agriculture and Food Systems. ed. Neal K. Van Alfen, Oxford, United Kingdom: Academic Press, pp. 78-97.

[11] Pardey et. al (2014) Investments in and the Economic Returns to Agricultural and Food R&D Worldwide. Encyclopedia of Agriculture and Food Systems. ed. Neal K. Van Alfen, Oxford, United Kingdom: Academic Press, pp. 78-97.

R&I invested in the transformative drivers [12]. First, as said above, rich counties have a special responsibility. Second, the combination of population growth, conflicts and extreme weather events raise pressing food insecurity concerns: 135 million people suffer acute food insecurity in 2019, half of them in Africa[13]. Third, the COVID-19 pandemic has exacerbated difficulties all over the world. Consequently, investing in EU agricultural R&I is now more than ever a priority to orientate sustainable food systems to the conflicting challenges of food security and preservation of natural resources.

PROMISING OUTCOMES AND WORRYING LIMITATIONS OF EU AGRICULTURAL POLICY

To reflect the priority of sustainable agriculture transition, the EU put knowledge at the heart of the objectives of the CAP. It also aims at boosting the AKIS (Agricultural Knowledge and Information Systems) of the EU Member States through multi-actor approaches[14] and co-designed programmes. The current Strategic Agenda for agricultural R&I makes the link with the SDGs and aims at speeding up the circulation of knowledge and the implementation of new innovative sustainable solutions[15] (Box 3).

Box 3: The strategic approach of EU agricultural R&I

Creating value from land - sustainable primary production

- Priority 1: resource management (notably soil, water, biodiversity)
- Priority 2: healthier plants and animals
- Priority 3: integrated ecological approaches from farm to landscape level

Enhancing rural innovation - modernising rural territories and policies

- Priority 4: new openings for rural growth
- Priority 5: enhancing the human and social capital in rural areas

[12] IEEP and SDSN (2019) 2019 Europe Sustainable Development Report, https://ieep.eu/publications/2019-europe-sustainable-development-report

[13] Global Report on Food Crisis (2020) FAO.

[14] The European Commission defines Multi-Actor Approach as "projects focusing on real problems or opportunities that farmers, foresters or others who need a solution ("end-users") are facing. It also means that partners with complementary types of knowledge – scientific, practical and other – must join forces in the project activities from beginning to end. As a result, those projects are able to develop innovative solutions which are more ready to be applied in practice and cover real needs." https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_brochure_multi-actor_projects_2017_en_web.pdf

[15] https://ec.europa.eu/programmes/horizon2020/en/news/final-paper-strategic-approach-eu-agricultural-research-and-innovation

Although the design of the strategy is widely acknowledged by the agricultural scientific community, it is still heavily dominated by the needs and concerns of producers, making the preservation of yield capacity and food security still the main shaper of the research agenda.

Wider needs and problems may not be regarded as requiring urgent sustainable future-proof solutions by the farmers taken individually, keen to protect their income first. Consequently, the GHG emissions of farming, the mitigation capacity of agriculture, protecting biodiversity, air and water, enabling regenerative agriculture to flourish, etc tend to occupy - by contrast - a secondary role in the conceptual making of the agenda.

Another striking limitation is the quasi absence of influence on policymaking: one distinctive feature of the 2018 CAP proposal is the change in its delivery system aiming at increased responsibility and flexibility for the EU Member States through the CAP Strategic Plans, a sort of administrative revamping. Interesting research findings on agro-ecology, organics or carbon storage have not been used for evidencing new policy instruments to support their adoption on a larger scale. CAP fundamentals do not change, with a strong 1st pillar providing per hectare direct payments favouring status quo whereas the transformative part of the policy, the rural development financed by the 2nd pillar, sees its budget reduced.

Looking at innovation and implementing innovative solutions in agriculture, one notable result is the booming European Innovation Partnership on Agricultural Productivity and Sustainability (EIP-AGRI), a toolbox to enhance place-based innovation through 'Operational Groups' bringing together farmers, advisors, researchers and enterprises. The EIP-AGRI which now counts some 1500 operational groups[16]. They form the backbone of the so-called multi-actor approach, which proved to be efficient for knowledge-generating and sharing, speeding up the dissemination of solutions. One reason for this success lies with the fact that specific complexity characterises on-farm decision-making, mainly due to the combination of two independent strands of risk: the economic and financial risk for property and income, and the natural hazards on crops and livestock. To reduce risk, farmers tend to adopt new techniques insofar as they could engage themselves in their co-creation and have their say at their inception. In addition, they can observe their implementation on pioneer farms in the same region, providing living examples under identical agronomic conditions before they will replicate them locally. Hence the multiplication of operational groups, networking, living labs and experimental farms are strong assets for the EU agriculture transition and making swifter the return on R&I investment.

Beyond agriculture itself, R&I in downstream sectors are marked by public-private partnerships enjoying a large degree of autonomy in their agenda

[16] https://ec.europa.eu/eip/agriculture/en/eip-agri-projects/projects/operational-groups

and decisions. This is the case in the food sector with the EIT-Food[17] and in the non-food sector with the Bio-Based Industries Joint Undertaking[18]. Although including businesses is key for deployment and attracts private funding, the fragmentation of the R&I landscape hinder holistic development.

The diverse independent research agendas may not contradict each other as they pursue common general objectives of competitiveness and sustainability but the lack of interaction and synergetic drive poses serious limitations to respond to pressing global challenges. Correcting this could easily improve the return on investment and generate multiple co-benefits. An attempt in that direction is given by the Bioeconomy strategy, including an R&I agenda extending the bioeconomy sector to any downstream use – food and non-food – of primary products from land and sea (see Box 4).

Box 4: Bioeconomy

The updated Bioeconomy Strategy (European Commission, 2018) focuses on overall sustainability and circularity, around three main action areas:

1. Strengthen and scale-up the bio-based sectors, unlock investments and markets
2. Deploy local bioeconomies rapidly across Europe;
3. Understand the ecological boundaries of the bioeconomy.

NEW PATHWAYS FOR HORIZON EUROPE

Doubling the overall post-2020 EU R&I budget to €160bn - an independent high-level group chaired by Pascal Lamy called for this change in a report released in July 2017[19], calling it the "*best investment the EU can make*". The group considered €120bn as a bottom line under which the EU's commitment to deliver on its political priorities would be called into question. The European Parliament supported this last figure for Horizon Europe. In 2020, political realities led the EU budget to be revised downwards. This triggers burning questions for agricultural R&I: would the announced €10 bn ring-fencing for "food, agriculture, rural development and the bioeconomy" be

[17] The EIT-Food gathers together 50 partners from 13 countries in a consortium, partly funded by Horizon2020. They leading businesses, research centres and universities providing education and training programmes, supporting start-ups and consumer-driven R&I projects. https://www.eitfood.eu

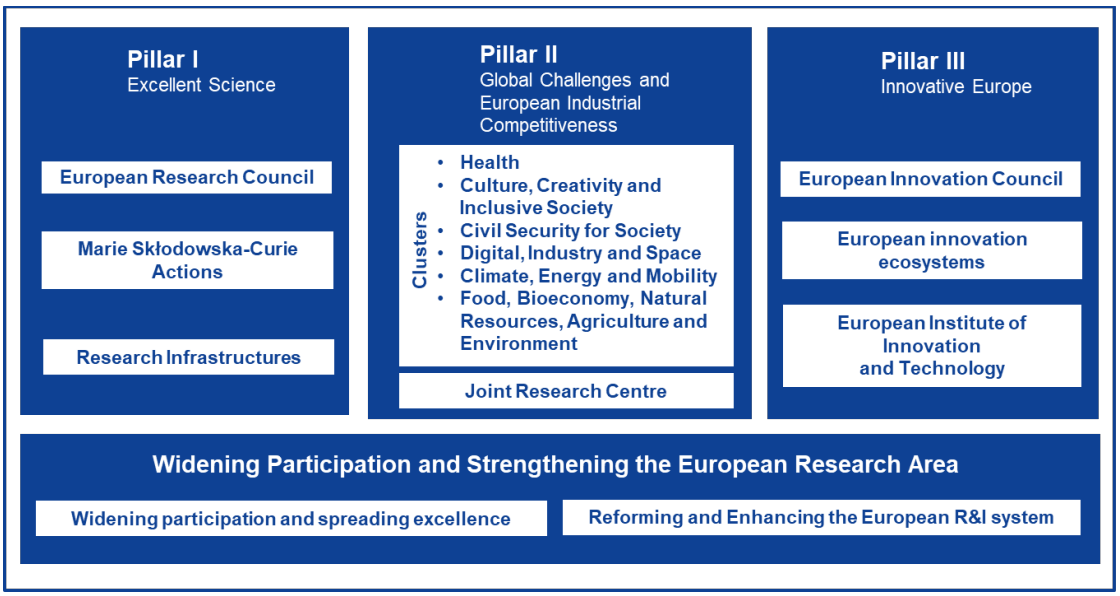
[18] The Bio-based Industries Joint Undertaking (BBI JU) is a public-private partnership between the EU and a consortium of industries, the BIC, aiming to develop the sector in Europe. It is partly funded by Horizon 2020 and implements its own Strategic Research and Innovation Agenda through yearly calls for proposals. https://www.bbi-europe.eu

[19] European Commission (2017) LAB-FAB-APP, investing in the Europe we want http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/hlg_2017_report.pdf

preserved? How will the budgetary cuts be distributed within the initial €100bn proposal made by the European Commission in 2018? Will the high expectations on return on agricultural R&I investment be met?

To examine this question, one needs to look at the legal texts of the proposal. Horizon Europe retains the same three-pillars architecture as Horizon 2020, introduces novelties like the missions[20] and revisits the complex partnerships[21] regimes. Programmes of collaborative research along the "Societal Challenges" of Horizon 2020 become "Global Challenges and European Industrial Competitiveness" of the Pillar II of Horizon Europe. Among them, the "Cluster 6" puts together "Food, Bioeconomy, Natural Resources, Agriculture and Environment" (see Figure 1). Its indicative budget is set at €10bn in the legal text of the proposal.[22] The precise budgetary resources for EU agricultural resources will therefore depend on the outcome of the final MFF negotiation in 2020, a top priority of the German Presidency.

Figure 1: 'Structure of Horizon Europe - Pillars and Clusters'



[20] Missions are a portfolio of actions, including R&I projects, intended to achieve a measurable goal within a set timeframe, with impact for science and technology and/or society and citizens that could not be achieved through individual actions.

[21] Partnerships bring together a broad range of actors, public or private, such as industry, universities, research organisations, local public bodies or civil society organisations including foundations and NGOs. The partners commit to jointly support the development and implementation of a programme of research and innovation activities. Horizon Europe foresees three levels of partnerships: co-programmed (each partner keep its financial rules), co-funded (each partner contributes to the financing of the partnership, with common financial rules) and Institutionalised (a specific independent body will manage the partnership, either public-public or public-private)

[22] Article 9 of the legal proposal for the Framework Programme (European Commission COM (2018)435 final of 7 June 2018) details indicative amounts between pillars and clusters. Furthermore the whereas clause n°7 of the parallel legal proposal for the Specific Programme says "*Reflecting the important contribution that research and innovation should make to address challenges in food, agriculture, rural development and the bioeconomy, and to seize the corresponding research and innovation opportunities in close synergy with Common Agricultural Policy, relevant actions under the Specific Programme will be supported with EUR 10 billion for the cluster 'Food and Natural Resources' for the period 2021-2027.*"

The co-creation and co-design of R&I orientations for the next programming period generates a series of discussions, consultations and open exchanges amongst stakeholders, policy-makers, businesses, the scientific community and all types of partners which took place along the year 2019. It led to an intermediate document that was released by the Commission and provides more details on the expected impacts and the corresponding necessary R&I orientations, as well as on missions and partnerships (see Box 5 and Box 6).

This new landscape for R&I in agriculture, bioeconomy and environment was well received by the EU member states, the European Parliament and the scientific community. The focus on digitalisation is frequently quoted as a good orientation to make agriculture more sustainable through the internet of things, artificial intelligence, precision farming techniques etc. However, the claimed alignment to the UN Sustainable Development Goals (SDGs) frequently repeated in the various official texts would merit more attention in their operationalisation. How will we walk the talk? In the case of agriculture, SDG 2 (zero hunger), 12 (responsible consumption and production), 13 (climate action) 14 (life below water) and 15 (life of land) are of particular relevance. The set of indicators accompanying the 17 SDGs should serve for the evaluation of agricultural research and its Impact and would help to estimate better the multi-faceted returns on investment in R&I.

Box 5: Targeted impacts of Cluster 6 and key R&I orientations

R&I should produce impacts in the following domains:

- Climate neutrality/adaptation to climate change.
- Biodiversity decline/restoration of ecosystems
- Circular management and use of natural resources/prevention and removal of pollution.
- Sustainable agriculture, fisheries, aquaculture and forestry/food and bio-based systems/food and nutrition security for all within planetary boundaries.
- Balanced development of vibrant rural, coastal, peri-urban and urban areas.
- Governance models enabling sustainability.

Sketch of the key R&I orientations in the following subdivisions of Cluster 6 ("intervention areas"):

- **Environmental observations**: space-based and land and sea-based data for Earth observations, artificial intelligence, access to information, citizens involvement
- **Biodiversity and Natural Capital**: understand biodiversity decline, nature-based solutions, valuing natural capital

- **Agriculture, forestry and rural areas**: climate-friendly, resilient and socially inclusive agriculture and forestry systems; agroecology, urban farming, soil health, pollinators, anti-microbial resistance, place-based innovation, …
- **Seas, oceans and inland waters**: restoration of biodiversity, Polar research, new food sources
- **Food systems**: nutrition, food safety, food waste, alternative proteins...
- **Bio-based innovation systems**: use of biological renewable resources (biomass) as a substitute for fossil and mineral-based resources, valuing bio-waste, biotechnologies
- **Circular systems**: systemic circular solutions at the regional and local level, plastic recycle and reuse, metrics, urban water systems, water reuse, nutrients...

Box 6: Mission and Partnerships related to Cluster 6

Mission Soil Health and Food: the mission board fixed a target of 75 % of healthy soils in the EU by 2030.

Institutionalised partnerships (based on Articles 185 or 187 of the Treaty):

- **PRIMA** means "Partnership for Research and Innovation in the Mediterranean Area". It was created in 2017, bringing together mainly Southern EU member states and Mediterranean countries for 10 years to fund R&I for sustainable water management and productive agro-food systems in the particular context of the Mediterranean region.
- The BBI JU (Bio-Based Industries Joint Undertaking), already mentioned above. It is proposed to prolong the BBI JU actions with a new partnership **CBE (Circular Bio-based Europe)** fostering sustainable innovation for new local value from waste and biomass.

Other partnerships either co-programmed or co-funded:

- Towards more sustainable farming: agro-ecology living labs and research infrastructures
- European Partnership on Animals and Health
- Environmental Observations for a sustainable EU agriculture (Agriculture of data)
- Rescuing biodiversity to safeguard life on Earth

- A climate-neutral, sustainable and productive Blue Economy
- Safe and Sustainable Food Systems for People, Planet & Climate
- Water4All: Water security for the planet

As the key but not sole supplier, EU agri-food systems have an important role to play in enabling consumers to have **healthy, sustainable and affordable diets**. Half of the EU's adult population is currently overweight (EEA, 2020). This contributes to diet-related diseases and related healthcare costs. Agri-food systems have a part to play in supplying healthier and more sustainable diets and reducing overconsumption, from a public health perspective. "Sustainable" diets are those which have a relatively low environmental impact as well as being consistent with good health (Fischer and Garnett, 2016).

Studies estimate that livestock consumption should reduce by about 50% in the EU to align current intake of animal protein and fats with WHO recommended dietary guidelines (RISE Foundation, 2018; EAT, 2019; The Lancet Commissions, 2019). Such dietary and consumption changes would have significant impacts on production especially on livestock farms, primary processors such as abattoirs and secondary processors of animal products (Bas-Defossez *et al*, 2019).

The connection between agriculture, related agri-food systems and **human health** has received greater attention in recent years, not least in light of the current coronavirus pandemic. The risk of foodborne and zoonotic diseases, as well as diseases directly affecting humans, are one major aspect. Other concerns include notably the increase in antimicrobial resistance due to excessive use in the livestock sector, the impact of which is estimated to cause at least 25,000 deaths in the EU each year (Cassini *et al*, 2019; Harvey, 2016; ECDC *et al,* 2017). As seen above, negative impacts on human health also include unhealthy diets and poor nutrition, exposure to harmful chemicals notably certain pesticides, and from the emissions of pollutants in the air, soil and water.

KEYS FOR BOLDER AGRICULTURAL R&I AGENDA AND HIGHER RETURNS

A first idea is to adopt a genuine systemic approach. Progress was made when one compares with Horizon 2020 where agriculture and environment were in different Societal Challenges, hence different Work Programmes and different calls (SC2 and SC5).

However, domains seem sometimes to be simply put next to one another without pursuing further integration. Yet the SCAR had delivered an interesting recommendation for **a global integrated approach centred on food and food systems.** [23]

The authors point out that "*The main strength of a Food Systems approach is its potential to understand and consider the complexity in terms of interdependencies between different elements of the food system and to link biophysical, economic and social aspects. Moreover, it might contribute to highlighting the synergies and trade-offs between different components of the food system, as well as to better grasp the potential unintended consequences caused by interventions designed from a reductionist research approach*." This last remark is particularly important in the case of agriculture. Returns on investment may be lessened due to too narrow approaches. For example, long-shelve life tomato varieties may well respond to distributors needs but deceive consumers for their bland taste.

The Mission on Soil Health and Food should have greater ambition for bigger impacts on the daily life of EU and non-EU citizens. It is good to build on past research and on the mechanics of living labs and on-farm experimentations similar to the EIP-AGRI to reach a target of 75% of healthy soils, but isn't this an intermediate step?

Where is the food dimension? IEEP recently published five recommendations for achieving this mission[24]. In the example, an ambitious objective to **turn EU soils into carbon sink** would directly serve the overall objective of climate neutrality set by the European Green Deal.

Other issues are fairly sensitive on the European political scene, but they are still missing or dealt with in a low-key way. Yet they are of paramount importance for the future of farming. What could be the return on investment be like if the research does not propose sustainable solutions to burning issues? Three examples of such issues are examined below; the EU would not deliver against its own objectives if the R&I does not adopt a bolder approach, thus endangering the return on investment in public research.

- Overuse of antibiotics in animal breeding over the years has triggered a solid antimicrobial resistance (AMR)[25]. This is frequently due to the regular use of antibiotics for preventing animal diseases in large factory farms. It poses a threat not only to animal health but also to human health. Although a partnership is envisaged in Horizon Europe, a more determined priority should be put on solving the problem, following the "One Health" approach. Why not **a specific mission to**

[23] Niels Halberg, Henk Westhoek, SCAR (2019) The Value Added of a Food System Approach in Research and Innovation https://scar-europe.org/images/FOOD/Deliverables/Policy_Brief_Food_Systems_RI-KI-03-19-466-EN-N.pdf

[24] IEEP (2020) https://ieep.eu/news/five-recommendations-for-achieving-healthy-soils-by-2030-through-horizon-europe

[25] http://www.fao.org/antimicrobial-resistance/en/

stop the spreading of AMR? It would echo the objective of reducing by 50 % by 2030 of antimicrobials sales for animal production set by the recent "Farm to Fork" Communication of the Commission[26]. The agricultural R&I part would look at alternatives to antibiotics and low-density animal breeding models.

- Pesticides use should also be cut by 50% by 2030. Attempts to reduce pesticide use in certain EU member states failed because the main instruments envisaged were the regulatory ones. The French plan "Ecophyto" ambitioned a 50 % reduction in ten years without success observes the French Court of Auditors [27]. One reason lies with the lack of proper dedicated research: a programme was launched in...2019. As a consequence, the government takes a step backwards by proposing the reauthorisation of neonicotinoids on sugar beet crops arguing the lack of alternatives. One lesson learned is that regulation is not sufficient to induce change. Practical solutions must be available simultaneously with regulation evolutions. Most regulatory changes are predictable, agricultural R&I should anticipate and **initiate massive research upfront to replace dangerous pesticides** by eco-friendly ones combined with renewed farming practices based on agroecology.

- Techniques allowing genome editing like *Clustered Regularly Interspaced Short Palindromic Repeats (*CRISPR) open promising avenues for developing faster interesting plant qualities, like resistance to drought or new diseases caused by climate change[28]. While it is true that the EU currently considers, after a Court of Justice judgment, that the New Breeding Techniques (NBT) fall under the Genetically Modified Organisms rules, groups of scientists wrote open letters calling for reviewing the situation[29]. Even the leaders of the German Green Party are calling for such revision[30]. EU R&I should invest in the matter beyond fundamental research and **develop a sustainability check for plant breeders and users.**

CONCLUSION

Investments in EU agricultural R&I will bring positive economic returns, thanks to crop yield preservation and integration of new technologies (e.g. digitalisation), in the prolongation of traditional trends. They will also bring a much wider spectrum of benefits to society if adequately calibrated to

[26] European Commission (2020) A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, COM (2020) 381, Brussels 20.05.2020

[27] https://www.ccomptes.fr/fr/publications/le-bilan-des-plans-ecophyto

[28] https://www.europeanscientist.com/en/agriculture/how-can-crispr-technology-improve-crop-breeding/

[29] https://www.eu-sage.eu/sites/default/files/2020-07/Open%20Statement%20EU-SAGE%20July%202020_EN.pdf

[30] https://www.europeanscientist.com/en/features/german-green-party-leaders-call-in-favour-of-the-new-biotechnologies-nbt/

attack in-depth societal issues of decarbonisation, biodiversity regeneration and global health protection. Returns on investment in agricultural R&I are multi-faceted and they should be measured in a multi-faceted way – an approach that itself warrants further research effort.

The Institute for European Environmental Policy (IEEP) is a sustainability think tank with offices in Brussels and London. As a not-for-profit research organisation with over 40 years of experience, we are committed to advancing evidence-based and impact-driven sustainability policy across the EU and the world.

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