European Commission

An ex-post evaluation of the rationale, implementation and impacts of EU Seventh Framework Programme (2007-2013), Cooperation Theme 2: FOOD, AGRICULTURE AND FISHERIES, AND BIOTECHNOLOGY

Report to the European Commission

Research and Innovation

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An ex-post evaluation of the rationale, implementation and impacts of EU Seventh Framework Programme (2007-2013), Cooperation Theme 2: FOOD, AGRICULTURE AND FISHERIES, AND BIOTECHNOLOGY

Report to the European Commission

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FOREWORD

The purpose of the food, agricultural, fisheries and aquaculture, and biotechnology collaborative research supported in Seventh Framework Programme (FP7) is to improve the economic, social and environmental effects of farming, fishing and forestry and the industries that depend on them. The European Commission's broad intention was to bring together science, industry and other stakeholders to contribute to the development of the 'Knowledge-Based Bio-Economy (KBBE)'. This purpose is served when research is used to deliver new practices, technologies and products, and to support evidence-based policy-making and better decisions (including decisions made by consumers). In early 2014, the European Commission (EC) asked us to assess the rational, implementation and achievements of this research. This document sets out the results of our work.

It was clear to us early in the work that 'top-down' methods of analysing research performance such as using bibliographic analysis, patent searching, and searching policy documents were unlikely to provide the evidence needed. Consequently, we decided to take a bottom-up approach. We examined the development and the full range of outputs of projects. We looked at about one third of the projects in the Cooperation Theme 2 research portfolio in detail ranging from projects that are completed to projects that have just started. Data on outputs alone are not sufficient and so we examined how research was made available to users. We used our experience to assess the implications of the research results.

Our work revealed some clear and consistent messages. These have implications not just for the content of future research but also for its structure and management. We decided therefore to provide a number of recommendations relevant to the strategic direction of research along with the conclusions of our assessment.

The European Union's involvement in this research area extends back to the earliest days of the European Union. We hope our work is a contribution to the development of the research so that impact for Europe is increased further.

The expert panel.

Abbreviations

ARD	Agricultural research for development
BRIC	Brazil, Russia, India and China
CAP	Common Agricultural Policy
CCRF	Code of Conduct for Responsible Fisheries
CFP	Common Fisheries Policy
CP	Collaborative project
CSA	Coordination and support action
EATiP	European Aquaculture Technology and Innovation Platform
EC	European Commission
ERA	European Research Area
ERA-NET	European Research Area Network
EAFM	Ecosystem approach to fisheries management
ETP	European Technology Platform
EU	European Union
EU15	The 15 countries who joined the EU before 1 May 2004
EU12/13	The 12 or 13 member states that joined the EU on or after 1 May 2004
FA	Fisheries and aquaculture
FAFB	Food, agriculture, fisheries and biotechnology
FAO	Food and Agriculture Organization of the United Nations
FMO	Fisheries management organization
FP	Framework Programme
HES	Higher education establishment
ICES	International Council for the Exploration of the Sea
ICPC	International Cooperation Partner Country
IMP	Integrated Marine Policy
IPR	Intellectual property right
JPI	Joint Programming Initiative
MS	Member State
KBBE	Knowledge Based Bio-Economy
MSFD	Marine Strategy Framework Directive
MPA	Marine protected area
MSY	Maximum sustainable yield
NCP	National Contact point
NGO	Non-government organization
OTH	Other types of participants
PRC	Private for profit organisation
PUB	Public body
REC	Public research establishment
RFO	Research funding organisation
RPO	Research providing organisation
SME	Small and medium-sized enterprises
UNCLOS	United Nations Convention on the Law of the Sea
UNIA	United Nations Implementation Agreement for the conservation and management of straddling and highly migratory stocks
WSSD	World Summit on Sustainable Development

Glossary

Definitions of some terms as they are used in this report are provided here.

Activity (definition as used in the work programmes)
The first level sub-division of the FAFB Theme of the FP7 Cooperation Work Programme. There were four Activities: sustainable production and management of biological resources from land, forest and aquatic environments (2.1, Agriculture and fisheries); fork-to-farm: (including seafood), health and well-being (2.2, Food); life sciences, biotechnology and biochemistry for sustainable non-food products and processes (2.3, Biotechnology); and other activities (2.4).

Annual work programmes
These are the documents setting out the calls for individual research projects arranged according to Activities and Areas. The annual work programmes also set out some policy context and relevant programme-wide objectives such as the inclusion of SMEs.

Area (definition as used in the work programmes)
The second-level sub-division of the FAFB programme in each of the Activities.

Bio-based industries
The bio-based industries are the industrial sectors outside the traditional wood products sector that use renewable raw materials for industrial processing into non-food products such as advanced transportation fuels, chemicals, and other materials.

Bioeconomy
The bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, renewable non-food products and bioenergy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical and energy industries. The relevant food, forestry and new non-food sectors have a turnover of about €1.5 trillion in the EU, about €1 trillion of which is in food chains. The traditional forest-based sector (wood, paper and pulp) accounts for most of the remaining €0.5 trillion. Novel non-food uses such as chemicals, plastics and bio-active compounds account for less than €60 million.[1] [2]

Biotechnology (general)
The application of knowledge for the improvement of organisms for an industrial or agricultural process or the application of a process involving the use of organisms.

Biotechnology (FAFB research activity)
The biotechnology theme as Activity 3 under the FP7 Cooperation Programme Theme 2 (FAFB). The full title of the activity is 'Life sciences, biotechnology and biochemistry for sustainable non-food products and processes'.

Cross-thematic funding
The funding of projects from more than one FP7 theme. There were 10 themes of which FAFB was one. Cross-thematic funding is used to support projects with funding from several themes, for example from FAFB and environment.

Description of Work (DoW)

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[1] Clever Consult, 2010. The knowledge-based bioeconomy in Europe: achievements and challenges.

[2] BECOTEPS 2011. The European Bioeconomy in 2030 - Delivering sustainable growth by addressing the Grand Societal Challenges, March 2011 (the White Paper from the BECOTEPS project)

The DoW is the project plan as appended to the contract. It is based closely on the research proposal submitted in response to the call topic. The DoW is typically a long and complex document setting out the background, research plans, allocation or resources and responsibilities in detail.

ERA-NET
An ERA-NET is a collaboration between national and regional public funding bodies of the Member States and Associated States. Through the ERA-NET scheme, the EU funds the networking of activities conducted at national or regional level to enable the mutual opening of national and regional research programmes. The scheme enables national systems to take on tasks collectively that they would not have been able to tackle independently.

Framework programme
The European Union's investment in research, technological development and innovation is organised in Framework Programmes that bring together a diverse range of European research activities. There were seven Framework Programmes until 2013. The framework programmes up until Framework Programme 6 (FP6) covered five-year periods, but from Framework Programme 7 (FP7) ran for seven years.

Food, agriculture and fisheries, and biotechnology (FAFB)
This is one of 10 thematic areas (Theme 2) in the Cooperation programme of the European Union's 7th Framework Programme for Research, Technological Development and Demonstration Activities (FP7).

Innovation
Innovation is finding a better way of doing something. Innovation differs from invention in that innovation refers to the use of a better novel idea or method, whereas invention refers more to the creation of the idea or method itself.

Joint Programming Initiative (JPI)
An EU supported mechanism to facilitate strategic coordination of national research programmes. JPIs engage in joint programming to pool national research efforts in order to make better use of Europe's public R&D resources and to tackle common European challenges more effectively in a few key areas. The focus is at the programme level complementing ERA-NETs that pool resources at the project level.

Technology transfer
Technology transfer is the process of transferring skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments or universities and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services.

Thematic area
Thematic areas are the areas addressed by each of the evaluation panels. These panels were food, agriculture, fisheries and aquaculture, and biotechnology. The thematic area panels provided the primary evidence for the evaluation.

Topic
The text in annual work programmes where the European Commission sets out the requirements at the project level. Each project is set up in response to a topic. Each topic describes the research required in the project, the background and purpose, and the expected impacts. It also sets out any specific requirements such as a minimum of funding going to SMEs.

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1 Executive summary

The European Commission (EC) asked us in early 2014 to conduct an evaluation of collaborative food, agriculture, fisheries and aquaculture and biotechnology research activities within the Seventh Framework Programme. This is a summary of our report. The research covers all aspects of the production, protection and use of biological resources from farms, forests and fisheries, including the food industry, food-related consumer issues, and the application of biotechnology for non-food uses. The portfolio comprises 515 projects with a total EU contribution of €1,837 billion. In the operational period, (2007 – 2013), seven annual work programmes with 440 topics (project calls) setting out individual project requirements were launched. This programme had an average annual budget of approximately €270 million. This is comparable to the investment in corresponding research made at national level by just one medium to large member state.

Because most of the research is not complete, we focused on the EC's annual work programmes and the resulting project plans. For the projects we examined, we considered the whole project life-cycle from the description of the research requirement in the work programme, the project plan, and major outputs as set out in the project report along with other communications such as project websites.

Rationale

The goals set out at the programme level are broad socio-political and economic goals. Individual project calls (topics) set out required project outputs and outcomes. From examination of the research projects and annual work programmes, we have identified five unifying themes underlying the research effort:

1. the management and protection of biological resources to secure food and non-food materials in a resource-constrained world;
2. supporting competitive economic activity while protecting the environment;
3. human health;
4. animal welfare; and
5. social and political inclusion.

Research on the primary resource base accounts for 48% of EU funds (31% in agriculture and forestry, 9% in fisheries and aquaculture, and 8% in biotechnology). The emphasis on supporting and protecting primary production is a major strength of the programme. Complementing on-going themes such as animal health research, the programme supported plant and animal breeding, improvements in farming systems, forestry, and control of production diseases of animals. The fisheries and aquaculture research in particular reflects a deep understanding of the current challenges. There was also a significant investment in 'enabling' research that seeks to draw on basic biological research. This is highly focused on impact on science and is far from farm or policy practice. There is relatively little emphasis on terrestrial biodiversity outcomes, especially those that depend on whole-farm or landscape-scale action.
Although quite defined in scientific terms, the food research covers a clearly framed set of research activities serving a very diverse set of outcomes with 27% of FAFB funding. The breadth of outcomes served is covered in just one sentence in the 2007 and 2008 annual work programmes providing little insight into the rationale.

The biotechnology activity is the largest of the FAFB activities in terms of funding (32%), mostly serving the emerging bio-based industry. The research projects are effective in generating new knowledge and there are notable successes. There is a clear expectation of a rich yield of intellectual property relevant to reducing dependence on fossil energy resources. However, from the annual work programmes, we found it difficult to identify a clear rationale for the biotechnology activity and there are a number of strategic weaknesses in the research as a result. Biotechnology is not a market sector, just one means of serving many applications and markets. Individual topics requested strategic biotechnology research combined with the application of biotechnology to specific non-food applications and markets without justification of these applications or without justification of the special contribution biotechnology can make compared with other means.

During FP7, the participation of SMEs was increased, in some areas call topics became less prescriptive, and there was an increase in systems research. However, the merits if these developments in terms of wider impact are not always clear. We draw attention to the risk that individual projects seek to address too many programme objectives reducing focus on key targets and impacts. A significant number of topics offered 'bottom-up' (non-prescriptive) research opportunities to the extent that the main research goal is left to proposers to decide but at the same time consortia were required to address numerous conditions. The programme addressed some research themes late, in some cases after related national research was well advanced or completed. This is not necessarily detrimental to impact.

Implementation

The research projects are thoroughly managed and achieve all or most of their objectives. There is also a commitment to a combination of scientific and wider societal impact that is rare in national or private sector research. The programme is supporting broad-based effective consortia and the commitment to collaboration is clear.

The EC programme managers have been remarkably successful in meeting programme management goals. The drafting of individual topics requirements was the main means of delivering on these targets and this contributed to the risk of projects trying to do too much as discussed above. There is evidence of some rather simplistic research management ideas behind what the EC requested in topics, for example that non-prescriptiveness fosters innovation.

There was emphasis on pluri-disciplinarity, and projects generally combined a range of disciplines. But there was some variation in the depth of this pluri-disciplinarity. For example, the fisheries and aquaculture research sometimes had relevant social-sciences questions being addressed by people not formally trained in the relevant disciplines.

Our work included consideration of the geographic distribution of the participants. With only 14 exceptions (from 515 projects), coordinators of FAFB projects were from the EU15 countries. The project participants were also predominantly from the EU15. Eight per cent were from the EU13, 6% from Associated Countries, 2% from Candidate Countries and 8% from ICPCs. Within the EU15, and within activities in particular, there is some evidence of concentration of research leadership in relatively few research organisations.

There are notable project funds dedicated to contract administration. Despite the effort put into project administration, the quality of formal reporting to the public is very variable. The record of projects available to the public is usually either fragmented in the scientific literature or is temporary on project websites.

Impact

Six broad target groups of end-users of research were identified. These are:

- farmers, foresters, fishermen and other primary producers in supply chains;
- technology providers, the service and input supply sectors, e.g. breeders, forest management and planning services, fisheries management bodies;

- the food industry, related health professionals, NGOs, and consumers;
- the non-food bio-based industries;
- policy-makers; and
- other scientists.

The range of primary users of food research outputs is particularly wide reflecting the diversity of strategic goals behind the research. The primary users of 'public good' consumer and nutrition research are the research community who inform consumers and the food industry. The food processing research impacts on the food industry directly, while research relevant to food safety is delivered mainly through regulators and other public agencies. Of particular interest is food systems research which impacts on a wide range of users including organisations interested in corporate responsibility.

The commitment to wider impact at project level (discussed above) combined with the high impact on science (discussed below) is a distinguishing feature of this research. There is significant impact through education evident from the staffing of projects with early career scientists, although the outcome is not routinely explicitly reported. Through successive programmes of research, Europe now has direct access to a well-integrated research and innovation community for which international collaboration is second nature and which is committed to interaction with a wide range of users.

We identified significant decisive technological impact in research addressing the protection and exploitation of biological resources. This includes the control of notifiable animal diseases, plant diseases, treats to our forests and the value of forest ecosystem services, and in research supporting the CAP, the CFP, and related policy areas. Many of the technological impacts cannot be quantified or assessed by conventional measures of commercial innovation. For the projects already completed, about one fifth of consortia have taken out at least one patent with a total of 52 patent applications from 107 completed projects.

Most projects delivered or are delivering significant outputs into the public domain. Despite the significant effort made in administration and reporting to the EC, reporting in general is be-spoke, variable in quality, and without the benefit of a standard reporting framework accessible to the public. Public access to many outputs declines after the end of the project.

Our short analysis of the evolution of Framework Programme research over twenty years shows a steady increase in emphasis on wider impact. However, the programme remains essentially about funding research driven largely by the academic community with the EC focused on preparing calls and managing research contracts. There are relatively few examples of a strategic approach to developing impact that would be expected in research driven by innovators or other users. Only 7% of projects are coordinated by SMEs. Many SMEs describe themselves as providers of services, particularly in agriculture and fisheries. Instead of developing pathways to deliver impact to design the research to deliver stated impact goals, we suspect that there has been rather simple blanket reliance on some features and mechanisms. Successive Framework Programmes have increasingly emphasised the involvement of SMEs to the point where allocation of EU funding to SMEs was required in many projects in the later stages of FP7. However there are frequent cases where SMEs seem to be involved more in the primary research rather than in using commercial expertise to develop impact. Private sector involvement in research is valuable and essential to impact in many circumstances, particularly where the main research outputs support new commercial products and processes. In these circumstances, the private sector could be playing a role in projects at levels higher than 25%. There are also situations where the private sector has a collective interest in research that is not effectively served by the involvement of individual SMEs.

Another common approach to increasing commercial impact is to integrate research at the project level along supply chains. It was a notable feature of agriculture and biotechnology research in particular. The associated addition of requirements expressed in call topics leads to topic texts which are unclear. As we have seen in case studies in the agriculture thematic area, the outcome of non-prescriptive topics with requirements to integrated along supply chains is unpredictable in terms of impact on target areas. A combination of non-prescriptiveness and ambiguity of topic requirements can reinforce the role of leading programme participants who are in a position to participate in several proposals in a single topic competition.

Recommendations

We make 12 recommendations. These address more pro-active and strategic portfolio or programme management; the need to avoid a "break with the past" between successive programmes; the use of a 'project form should follow function' principle in determining project requirements; revision of contract reporting and reporting of the research to the public; the establishment of central systems to provide common project communication materials in a standardised and more permanent way; the testing of topic texts for clarity and focus; and efforts to strengthen the capacity of researchers in the newer Member States to lead research.

The recommendation that encourages more pro-active and strategic portfolio or programme management requires particular mention here. It means that a clear scientific framework should guide the development of call topics and thus facilitate the establishment of effective research portfolios that drive impact in target areas. Adopting strategic programming at the level relevant to specific science and technology outcomes is a very significant undertaking. It identifies research objectives at the programme level supported by the assessment of the current status of research and development. It sets out the development of pathways through which the research outcomes can be reached. This research programming is a skilled and demanding task that requires deep scientific understanding combined with knowledge of the impact areas targeted. The overall effect is to raise the focus of research leadership (both in the EC and within stakeholder groups and supporting member state institutions) above the level of individual projects and focus it on higher level specific research and innovation outcomes and their relationship to societal goals.

2 Introduction

This report sets out the findings of an ex-post evaluation of the rationale, implementation and achievements of EU funded collaborative research activities in the area of Food, Agriculture, Fisheries and Biotechnology (FAFB) within the Seventh Framework Programme (FP7) for Research and Technological Development.

Running from 2007-2013, FP7 was designed to respond to Europe's needs for boosting employment, competitiveness and quality of life and it is a key tool to maintain European leadership in the global knowledge economy.

The two main strategic objectives of FP7 were to strengthen the scientific and technological base of European industry; and to encourage its international competitiveness, while promoting research that supports EU policies.

FP7 was made up of four specific programmes plus a fifth one on nuclear research:

- Cooperation (supporting collaborative research and networking)
- Ideas (which funds the European Research Council)
- People (which supports the mobility of individuals through Marie Curie actions)
- Capacities (which supports a range of actions, including international cooperation and support for European infrastructures)
- Nuclear research

The non-nuclear research activities of the Joint Research Centre (JRC) are grouped under another specific programme.

The research covered by this evaluation is all under Cooperation, which is the main mechanism to fund goal-oriented research. Within Cooperation, FAFB research is brought together as a theme (Theme 2) covering the commercial exploitation of biological resources which accounts for €1.5 trillion per year[3] in economic output employing about 22 million people. A total of €1.9 billion was allocated to FAFB research from a total FP7 budget of €50.5 billion of which €32.4 billion was allocated to Cooperation.

2.1 Mandate

The Terms of Reference are provided in Annex 1. They required us to consider three main aspects of the FAFB programme:

- rationale: an analysis of the logic of intervention, the relevance of its objectives and whether the objectives are consistent with the strategic context and the identified challenges;
- implementation: the effectiveness and efficiency of the intervention, and
- achievements and impacts: the concrete outcomes and impacts of the intervention.

As an overall guide, we were asked to consider if the seven annual work programmes had “done the right thing” and that the procedures were leading to “doing things right”.

[3] EC 2006. Annual work programme 2007-2008. Cooperation. Theme 2. Food, agriculture and fisheries, and biotechnology.

2.2 Methodology

The European Commission identified us as 20 experts. Sixteen of us were grouped into 4 thematic panels according to the four FAFB activities: food, agriculture, fisheries and aquaculture, and biotechnology. An additional 5th horizontal panel was set up to examine some cross-cutting support projects. The experts agreed on the most important indicators for their evaluation. The whole panel was chaired by Dr Yvon Martel from Canada. The evaluation was done between February 2014 and August 2014. The EC provided the experts with access to programme data. Each project was allocated to one of the five thematic panels.

The realisation of impact from research outputs by end users can take decades. With this lag-time there is also a diffusion of research results. This means that even if we had the benefit of observing impact decades after the research giving rise to it is completed, it is difficult to attribute impact to specific pieces of research. Consequently, it is very rarely possible to assess the impact of long term strategic research by direct observation.

In addition, an assessment of impact of a programme that is not yet complete is necessarily a predictive exercise. At the start of the evaluation, only 107 of the 515 projects were completed and formally reported. For the other projects, we could only examine the project plans (Descriptions of Work), and existing or expected outputs.

We adopted several approaches examining the life-cycle of research projects including the following:

1. an examination of the relationship between the programme-level research goals and the socio-political drivers behind the programme;
2. an examination of the topic texts and the programme-level research goals and expected impacts;
3. an examination of the relationship between the research as agreed with the EC in the projects' 'Descriptions of Work' (DoW) and the EC's topic calls; and
4. an examination of the performance of research conducted.

The panels agreed on a common approach to collecting quantitative information. The analyses involved an examination of the Description of Work (DoW) of each project and a comparison with the call text and topic to which it responded, followed by an examination of the interim and final reports and their assessments, as well as an examination of the project website, and other information if available (flyers, posters, conference presentations, publications). Through these examinations, we collected (quantitative) data, e.g. the countries the project partners were from, publication outputs, type of partner organisation, and these data complemented the expert judgment on more qualitative issues. Complementing this, 'top-down' analyses of large programme data sets were conducted and these resulted in most of the data referred to in this report.

Each thematic panel comprised four experts but there were differences between panels in terms of the scope and size of the research portfolios, and therefore their approaches. The food panel took a stratified approach related to stage of progress of the 132 projects allocated. Two experts evaluated each of the final reports of 29 completed projects and evaluated the periodic reports of 17 almost finished projects. Another representative 40 projects were selected among recently started projects, each for evaluation by one expert. For 22 of these a periodic report was available for the evaluation. The description of work only was used for the evaluation of another 18 projects. In addition 2 international cooperation projects were evaluated.

The agriculture thematic panel had the broadest portfolio with 188 projects. The panel considered impact pathways within case studies, with each case study focused on research covering a target impact area. The panel identified 38 target impact areas in the research portfolio. These are clusters of projects that address specific groups of users and applications. Eleven of these, comprising a total of 56 projects (30% of the portfolio), served as case studies.

The fisheries and aquaculture panel based their analyses on 46 projects. Only 15 of these had been completed. Twenty-one (21) projects were ongoing and nine (9) projects started as late as January 2014.

The biotechnology panel based their analysis on 139 projects divided between 7 research areas. The majority of the projects are still progressing and therefore any statements concerning impact are based on expert judgment of the expected outputs.

The horizontal panel examined all six completed projects (out of 11 allocated to the panel).

2.3 Programme resourcing, scope and background

The FAFB FP7 portfolio comprises 515 projects. The programme started in 2007 picking up from FP6, and the last research projects will be complete in 2018. In the operational period, (2007 – 2013), 440 topics for research proposals in this area were launched in seven calls. The distribution of projects as classified by the EC across the FAFB thematic areas is summarised in Table 1.

Food (Fork-to-farm (including seafood) health and well-being – Activity 2): The food activity of the FAFB programme is entitled "Fork to Farm: Food (including seafood), health and well-being" reflecting the effort to research along a reversed food chain starting from the consumer preferences for foods for health and well-being and acting on these preferences through the retail, packaging, processing and primary production steps of the food chain. The 5 different research areas are: consumers; nutrition; food processing; food quality and safety; environmental impact and the total food chain. Area 6 provided funding opportunities to supporting activities for the European Research Area, e.g. ERA-NET projects.

Agriculture (Sustainable production and management of biological resources from land and forests – part of Activity 1): The agriculture programme covered all aspects of the management and use of terrestrial biological resources, including animal production and breeding, animal health, animal welfare, crop and grassland production, natural resource management, forestry, plant heath and all related policy. This research relates to all European agricultural and forestry activity which accounts for nearly 80% of the EU land area. The portfolio was separated into four main areas: enabling research (1.1); sustainable primary production (1.2); animal health and welfare (1.3); and research for policy (1.4). There was considerable overlap between these programming areas with respect to research content and impact targets and so for the purposes of this evaluation and to help describe the research, 38 impact areas served by five broad areas of science were identified.

Fisheries and aquaculture (Sustainable production and biological resources from aquatic environments – part of Activity 1): For programming purposes, the fisheries and aquaculture research was embedded in area 1.2 shared with agriculture. It therefore is not a separate category of research in the programme structure used by the EC. EC officials managed the research according to six priorities which are not set out in public programme documents (e.g. the work programmes):

1. ecosystems approaches to fisheries management (EAFM) to support the reform of the CFP and the Marine Strategy Framework Directive (MSFD);
2. socio-economic dimension of fisheries and aquaculture;
3. governance of the CFP and its inclusion in the EU Integrated Maritime Policy (IMP); developing Marine Protected Areas (MPAs), integrated management of activities, and assessments of wind energy potential in the Mediterranean and the Black Sea;
4. biology of farmed aquatic animals and integration to the production cycle and policy development;

5. interactions between aquaculture and the environment; and
6. communication and dissemination, technology transfer and training.

Biotechnology (Life sciences, biotechnology and biochemistry for sustainable non-food products and processes – Activity 3): Biotechnology is, by definition, a means of doing something with a biological system. The focus of the programme was towards products or applications. To this end the biotechnologies portfolio was divided into the following areas:

1. novel sources of biomass and bio-products, novel high added value bioproducts and bioprocesses (3.1);
2. marine and fresh water biotechnology (3.2);
3. industrial biotechnology, novel high added value bioproducts and bioprocesses (3.3);
4. biorefinery (3.4);
5. environmental biotechnology (3.5); and
6. emerging trends (3.6).

Table 1 The project funding in evaluation thematic areas

Area code	Thematic areas	EU contribution (€ million)	No of projects	No of participations
	FOOD			
KBBE-2-1	Consumers	40	11	142
KBBE-2-2	Nutrition	142	25	454
KBBE-2-3	Food processing	123	35	558
KBBE-2-4	Food quality and safety	98	24	419
KBBE-2-5	Environmental impacts and total food chain	81	22	359
KBBE-2-6	European Research Area	14	9	127
KBBE-2-7	Coordinated call with India	3	2	12
	Other activities	2	3	42
	TOTAL (FOOD)	504	131	2,113
	AGRICULTURE			
KBBE-1-1	Enabling research	93	21	281
KBBE-1-2	Increased sustainability of all production systems	224	59	1010
KBBE-1-3	Optimised animal health, production and welfare	131	38	603
KBBE-1-4	Socio-economic research and support to policies	123	66	909
	Other activities	3	4	35
	TOTAL (AGRICULTURE)	574	188	2,838
	FISHERIES AND AQUACULTURE[4]			
KBBE-1-2	Increased sustainability of all production systems	99	27	509
KBBE-1-4	Socio-economic research and support to policies	20	12	137
KBBE-1-5	The ocean of tomorrow	46	7	146
	TOTAL (FISHERIES and AQUACULTURE)	165	46	792
	BIOTECHNOLOGY[5]			
KBBE-1-2	Increased sustainability of all production systems	3	1	23
KBBE-1-3	Optimised animal health, production and welfare	1	1	12
KBBE-1-4	Socio-economic research and support to policies	1	1	9
KBBE-1-5	The Ocean of Tomorrow	24	3	70
KBBE-3-1	Novel sources of biomass and bioproducts	111	27	388
KBBE-3-2	Marine and fresh-water biotechnology (blue biotechnology)	126	29	410
KBBE-3-3	Industrial biotechnology: novel high added-value bio-products…	115	28	325
KBBE-3-4	Biorefinery	65	13	200
KBBE-3-5	Environmental biotechnology	61	16	274
KBBE-3-6	Emerging trends in biotechnology	75	18	200
KBBE-4	Other activities	2	2	17
	TOTAL (BIOTECHNOLOGY)	585	139	1,928
	HORIZONTAL	10	11	114
	TOTAL FOR THE FAFB PROGRAMME	1,837	515	7,785

[4] Fisheries and aquaculture research was under the same activity as agriculture (KBBE 1).

[5] The biotechnology areas changed in 2009. These are the titles of areas from 2009 onwards.

3 Rationale and evolution

This section examines the logic of the programme intervention (i.e. an intervention in the market for research and development), the relevance of the programmes objectives, and whether the objectives are consistent with the strategic context.

The evolution from previous Framework Programmes is particularly relevant and we therefore start with a brief overview of the historical background. In terms of research policy rationale, we describe two distinct phases in FP7: the establishment phase and the first half of the operating period under the Lisbon objectives and the second half (2011 – 2013) that addressed Europe 2020 and related initiatives. We then describe the research goals as set out in the seven annual calls and the research these sought to fund. We follow this with an assessment of resourcing and changes in resourcing over time.

3.1 Historical background from FP5 and 6

A commitment to invest in the science-based improvement of agriculture and food goes back to the founding of the Common Agricultural Policy. Investment in FAFB research is one of the most longstanding EU activities. An understanding of the changes helps in assessing the drivers behind research in FP7.

Theme 2 (FAFB) has, through FP5 and FP6, its roots in the FP4 FAIR programme that operated from 1994-1998. Relevant policy debate in the mid-1990s was dominated by concerns of over-supplied markets in Europe, animal disease outbreaks and food safety implications of the BSE crisis. In addition, organic farming and its markets were on the rise. This policy environment had a major impact on the development of FP5 (1998 – 2002) and especially FP6 (2002 – 2006), which in turn provided the backdrop to the development of FP7.

Framework Programme 5 (1998-2002): The FP5 thematic programme '*Quality of life and management of living resources*' was aimed at enhancing the quality of life of European citizens and improving the competitiveness of European industry. This was partly a response to over-supplied food commodity markets. Key Action 5 (KA5) of this programme dealt specifically the sustainable production and exploitation of biological resources, with emphasis on research covering the whole production chain. Research on animal health and welfare, and natural resource protection expanded. Forest science focused on environmental performance, management, operations, and wood technology. Fisheries and aquaculture research promoted an integrated approach to the development of new concepts for the sustainable management and production linking resource conservation, means of capture, market requirements, reduced impact on ecosystems, diversification of cultivated species, improvement of production techniques and disease control. There was also emphasis on enabling biological research reflecting the expansion in the molecular biology at the time, and was manifested in a distinct programme area called 'Cell Factory' which was a precursor of the FP7 biotechnology activity.

FP5 marked a distinct change in direction from a science-led approach in earlier framework programmes towards an orientation on goals to support a better quality of life. A new proposal assessment system was introduced to focus on benefits for society. This was developed as the 'Impact' criterion in FP6 and FP7.

Framework Programme 6 (2002-2006): The public policy debate in the lead up to FP6 was dominated by food safety and animal health concerns. There remained also concerns about the over-supply of food from European farms. The word 'agriculture' was removed from the programme title. This, combined with the alliterative phrase 'from fork-to-farm', focused research on questions relevant to consumers with projects integrating diverse activities along reversed supply chains in Thematic Priority 5 ('Food Quality and Safety'). This meant that questions relevant to consumption were the starting point of all research. Agriculture in general and forestry in particular were side-lined in FP6, and even animal health and welfare was forced to rely on investment in policy-oriented applied research in a separate funding stream (Scientific Support to Policy (SSP).

Thematic Priority 5 “Food Quality and Safety” also supported better seafood and other marine resources production, improving the knowledge about diseases, health conditions and processing. However, as for animal health, the majority fisheries and aquaculture research was funded to address policy problems via pragmatic and much more applied research in the SSP funding stream.

3.2 Drivers at the outset of fp7

The FAFB programme (Theme 2 of FP7) set out to support Europe in a global economy while protecting our environment and social model. FAFB research was focused on the sustainable management, production and use of biological resources (farms, fisheries and forests). In addition, funds were allocated specifically to support life sciences and biotechnologies, particularly for research relevant to the bio-based industries.

At the outset, the FAFB research addressed the following needs which reflect the political priorities in the preceding years:

1. growing demand for safer, healthier, higher quality food;
2. sustainable use and production of renewable bio-resources;
3. increasing risk of epizootic and zoonotic diseases and food related disorders;
4. sustainability and security of agricultural, aquaculture and fisheries production;
5. increasing demand for high quality food, taking into account animal welfare specific dietary needs of consumers.

The programme foundations were laid mostly in 2005 and 2006 when it was becoming clear that the Lisbon Strategy to promote sustainable growth and social cohesion had weaknesses. It pre-dated Europe 2020 and it was developed prior to two crises that now dominate thinking: the global food crisis of 2007-2008 and the financial crisis that emerged in the same period.

There were a number of important driving influences at the outset of FP7, particularly the outputs of 7 European Technology Platforms and the work of advisory committees such as the Standing Committee for Agricultural Research (SCAR). The European Technology Platforms (ETPs) that informed the development of FP7 were Plants for the Future; Forest-based Sector; European Technology Platform Global Animal Health; The Sustainable Farm Animal Breeding and Reproduction Technology Platform; Food for Life; and the European Aquaculture Technology and Innovation Platform (EATiP). These platforms were developed under FP6. EATiP was the last to be launched in 2007 at the dawn of FP7. Their primary aim was to channel input from industry into the research prioritisation process. This was complemented by ‘mirror groups’ (European and national) from the public sector associated with each ETP.

A main driver in the food area was the concern about the safety of food chains, as well as diet-related diseases and food choices to help to fight diet-related disorders (e.g. obesity, allergies) and infectious diseases. The importance of the ETP Food for Life as a driver is also evident from the topics.

In agriculture, the Standing Committee on Agricultural Research (SCAR) brings together Europe’s Member State agricultural ministries to contribute to steering the European agricultural research effort. SCAR was formally mandated in 2005 to provide a revived role in the direction of European agricultural research. With that revival, an extensive research prioritisation process was established, largely with a public sector character, complementing the private sector emphasis of the ETPs. Its first major output was the results of the 1st

Foresight Exercise published at a conference in 2007.[6] Several SCAR Collaborative Working Groups based on national programmes were established, and some of these led to ERA-NETs. Among the SCAR Strategic Working Groups, the Agricultural Knowledge and Innovation Systems Group (AKIS) was essential to introducing a new innovation concept at the end of FP7.

Evident from the activities of the 1st SCAR Foresight exercise, priorities for agricultural and related research were very diverse included climate change, environmental and resource protection, food production to meet growing global demand, trade, energy, health, and rural economy. The first SCAR Foresight exercise also highlighted science and technology as a driver and identified 10 areas, one being biotechnology. The breadth of these challenges set up a general driver: the need to restore balance in the agricultural research effort. Agriculture and the food system are responsible for 20-30% of most categories of environmental burdens[7], including greenhouse gas emissions and these burdens arise mostly from the production phase. This and similar evidence at the time led to consensus that improving the environmental and resource performance of primary production combined with the growing global demand for foods were important drivers.

In forestry, the EU has a long tradition of supporting national measures and activities. The role of the EU in developing and implementing forestry policy was described in the EU Forest Action Plan (2007-2011)[8] which included an action to encourage research and development in FP7 and to encourage the development of the Forest-based Sector Technology Platform.

In fisheries and aquaculture, the main challenges at the outset were the formulation and implementation of the new Common Fisheries Policy (CFP) and its integration with the Marine Strategy Framework Directive (MSFD). Research needed to address ecosystem as well as socioeconomic objectives. In aquaculture, the main challenge was increasing production while meeting environmental, social and economic goals.

Both fisheries and aquaculture compete for coastal space and interact with the marine environment. Spatial planning, exploitation of mutual opportunities for development and vigilant monitoring of the aquatic environment at a sentinel level are crucial to European marine and maritime economic sectors.

There has been increasing political interest and public investment in the development of the non-food use of biological resources, an interest which can be traced back to measures to deal with over-supplied food commodity markets in the 1980s. In recent years the combination of efforts to reduce reliance on fossil fuels, reduce the environmental impact of products over their life-cycles, and the challenge of combating climate change has stimulated further interest in the novel non-food use of biological resources in emerging bio-based industries. Concurrent with these political and market developments, the advances in molecular biology and analytical biochemistry have produced many new tools that can potentially speed up plant and product improvement. Many of these advances were made in European laboratories and FP7 sought to strengthen this knowledge base through the biotechnology activity.

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[6] SCAR 2007. 1st Foresight Exercise. Towards future challenges of agricultural research in Europe. http://ec.europa.eu/research/agriculture/scar/foresight_en.htm

[7] Tukker, A, Huppes, G, Guinée, J, Heijungs, R, de Koning, A, van Oers, L, Suh, S, Geerken, T, Van Holderbeke, M, Jansen, B and P Nielsen. 2006. *Environmental Impact of Products (EIPRO). Analysis of the life cycle environmental impacts related to the final consumption of the EU-25.* Main report IPTS/ESTO project.

[8] COM 2006. On an EU Forest Action Plan. COM 302.

3.3 Internationalisation

International cooperation (i.e. collaboration between European partners and partners outside EU and associated countries) is the subject of EU research policy set out in successive EU treaties since 1986. Europe therefore had a long history of international cooperation. The intention to set up Specific International Cooperation Actions (SICA) was set out at the outset of the programme with two objectives: [9]

- to support and promote European competitiveness through strategic research partnerships with third countries by engaging the best third country scientists to work in and with Europe;
- to address specific problems that third countries face or that have a global character, on the basis of mutual interest and mutual benefit.

It was hoped that the international cooperation actions would relate to mainstream policy to support fulfilling international commitments of the EU and contribute to sharing European values, competitiveness, socio-economic progress, environmental protection and welfare under the umbrella of global sustainable development. In practice this meant developing and consolidating international links to access cutting-edge and complementary know-how; sharing the costs and risks with international partners; accessing skilled individuals; and accessing endemic research subjects, such as natural or social phenomena, which are limited geographically.

3.4 Development of drivers during FP7

The Lund Declaration[10] was the first major European statement on research policy that emerged during FP7 (in 2009). This presented a high-level statement of changes required to the European research system as a whole. It called for research processes to be based on understanding of the interaction between “bottom-up” and “top-down” initiated research. It also called for attention to be given to more systematic division of labour between European, national and regional research programmes; better links between research and policy; and a risk-tolerant and trust-based approach in research funding.

The Europe 2020 Strategy replaced the Lisbon Strategy. This is now the European Union’s ten-year growth and jobs strategy that was launched in 2010. It is about creating the conditions for a smart, sustainable and inclusive growth through more effective investments in education, research and innovation; a decisive move towards a low-carbon economy, and with a strong emphasis on job creation and poverty reduction. These are addressed by 7 flagship initiatives. The flagship initiatives are as follows:

Smart growth

- Digital agenda for Europe
- Innovation Union
- Youth on the move

Sustainable growth

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[9] EC 2006. Council decision of 19 December 2006 concerrning the specific programme “Cooperation” implementing the Seventh Framework Programme of the European community for research, technological development and demonstration activities (2007 to 2013). Official Journal of the European Union. L400/86. 30.12.2006.

[10] Swedish Presidency of the European Council. 2009. The Lund Declaration. Europe must focus on the grand challenges of our time.

- Resource efficient Europe
- An industrial policy for the globalisation era

Inclusive growth

- An agenda for new skills and jobs
- European platform against poverty

The Innovation Union initiative emphasises that research and innovation are key drivers of competitiveness, jobs, sustainable growth and social progress. This was manifest in the 2011 work programme with mention of the Innovation Union Initiative bringing together research and innovation to address major challenges. 'Resource efficient Europe' was particularly important in relation to this programme because it emphasises a significant transition in agriculture and alignment of the CAP to a low carbon economy.

There is a range of other policy documents such as the European Biodiversity Strategy[11] which are relevant. In addition, there were also more scientific or technical drivers emerging at Member State level, most notably the IAASTD report in 2009[12] which concluded that the main challenge for agricultural knowledge, science and technology is to increase productivity considering the multi-functionality of agriculture; the "Reaping the benefits" report[13] and the UK food and farming Foresight Report.[14] The UK Foresight Report drew attention to the confluence of demand growth, impact on the environment, constraints of the supply side and climate change as what was termed "a perfect storm". This was supported by the 3rd SCAR Foresight Report[15] in 2011 which highlighted the role of public agricultural research in supporting transition towards more sustainable food consumption and production in a resource-constrained world. The report drew attention to the need to take planetary boundaries seriously; resource scarcities; the need to better understand agricultural systems; diversity and resilience; the need to consider 'sufficiency' linking food consumption with production; fit-for-purpose agricultural knowledge and innovation systems; a long-term view in agricultural research policy; new ways of policy coordination; and the need for mission oriented research.

The Marine Strategy Framework Directive (MSFD) was adopted in June 2008, after several years of preparation. It made clear that science and technology support the reconciling of promotion of sustainable economic growth in sea-based activities with environmental conservation ("Blue Growth"). The European Strategy for marine and maritime research[16] recognised that RTD efforts are necessary to increase their eco-efficiency and offer solutions to overcome the unsustainable use of resources and a list of research topics requiring cross-thematic approach to reap the full potential of the seas were identified. The implementation of this strategy gave rise to the ambitious FP7 initiative "*The Ocean of Tomorrow*" with a total EU contribution of €196 million in 2010-2013 (cross-thematic FP7 funding). A part of this cross thematic funding (€79 million) came from the FAFB programme budget.

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[11] COM 2011, 244. **Our life insurance, our natural capital: an EU biodiversity strategy to 2020.**

[12] IAASTD 2009. Agriculture at a crossroads. International Assessment of Agricultural Knowledge, Science and Technology Development. Synthesis Report.

[13] Royal Society 2009. Reaping the benefits. Science and the sustainable intensification of agriculture.

[14] Foresight 2011. The future of food and farming. UK Government Office for Science.

[15] SCAR 2011. Sustainable food consumption and productin in a resource-constrained world. 3rd SCAR Foresight Exercise.

[16] COM2008. A European strategy for marine and maritime research. A coherent European Research Area framework in support of a sustainable use of oceans and seas

In addition, at the later phase of the period covered by the present evaluation, an important policy driver was the strategy for "Innovating for Sustainable Growth: A Bioeconomy for Europe"[17] adopted by the European Commission in 2012. This strategy proposes a comprehensive approach to address the ecological, environmental, energy, food supply and natural resource challenges. It was proposed by the Commissioner for Research and Innovation, and co-signed by the Commissioners for Agriculture and Rural Development, Maritime Affairs, and Industry and Entrepreneurship. The strategy covered the whole bioeconomy but included measures specifically relevant to the bio-based sector and thus to the biotechnology activity. It made reference to the Lead Market Initiative on bio-based products, the Blue Growth initiative, and the Renewable Energy and Fuel Quality Directives' targets and the Strategic Energy Technology plan. There was emphasis on infrastructural measures which related specifically to the biorefinery concept.

3.5 The direction of FAFB research in FP7 (2007-2013)

The FAFB programme was initiated through the publication of the 2007-2008 Work Programme. This set out the goal of building a European Knowledge-Based Bio-economy (KBBE) by bringing together all relevant actors (appropriate research disciplines and industrial sectors, farmers, forest owners, consumers, etc.) to develop the basis for new, sustainable, safer, affordable, eco-efficient and competitive products in line with the European strategy on life sciences and biotechnology and the Lisbon objectives. This overall goal remained throughout the programme's seven annual work programmes. This was expected to help increase the competitiveness of relevant European economic sectors, in particular through SMEs, while improving social welfare and well-being and reducing environmental footprints. The legal basis of FP7 included the target to allocate 15% of funding to SME participants.[18] For administration, the FAFB (Food, Agriculture, Fisheries and Biotechnology) programme comprises three main elements or 'Activities':

1. sustainable production and management of biological resources from land, forest and aquatic environments ('Agriculture' and 'fisheries');
2. Fork to farm: Food (including seafood), health and well-being ('Food');
3. Life sciences, biotechnology and biochemistry for sustainable non-food products and processes ('Biotechnology').

FP7 reintroduced agricultural production research with clear tangible farming and agricultural system targets. Biotechnology was merged into broad non-health biosciences in the FAFB theme with a trend to link together the product chain from organism to processed product. The result was increased support for research on bio-refineries, marine biotechnology, plant synthetic biology, cellular production platforms for materials, fine chemicals, including biopharmaceuticals, traits for biomass for energy applications, waste utilisation, environmental issues and cross-cutting sustainability issues.

Compared with FP6, FP7 was very significant in its emphasis on production agricultural research and its efforts to address farming and agricultural system targets, and therefore in line with the drivers already described. Over agriculture and fisheries, resource protection and management could be regarded as the major underlying theme. At the start, more emphasis was placed on small and medium size collaborative research projects (compared with FP6). As the programme progressed, there was increasing emphasis on the participation of SMEs, linked to a drive from the EC to support innovation. Projects also increased in size as the programme progressed, particularly in biotechnology from 2011 onwards.

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[17] COM 2012 60. Innovating for Sustainable Growth: A Bioeconomy for Europe.

[18] Decision No 1982/2006/EC of the European Parliament and the Council of 18 December 2006. Official Journal 30.12.2006.

The emphasis on the sustainable development of farming and forestry remained throughout with increasing support for international research (i.e. collaboration outside the EU). An effort to build capacity in strategic research relevant to forestry and genetic improvement generally through 'enabling research' was reinforced in successive annual work programmes. The 2011 call increased emphasis on the participation of SMEs listing topics where their participation was particularly encouraged or targeted. A number of topics in WP2010 were specifically designed to encourage participation by SMEs. From the 2011 work programme onwards, participation of SMEs was made a requirement for most projects.

International cooperation was strongly encouraged. Specific actions were undertaken to foster cooperation with priority partner regions and countries. Projects were to address the issues of policy support, networking, dissemination and civil society involvement through collaboration beyond EU borders.

The 2011 work programme introduced Europe 2020 as a driver with more support for generating knowledge to deliver new and more innovative products, processes and services. This included pilot, demonstration and validation activities. This phase also increased emphasis on climate change mitigation and adaptation in agriculture and low carbon and resource efficient industry. All topics published in the 2011 work programme were presented as contributing to at least one of the following five societal challenges:

1. primary production mitigating and adapting to climate change;
2. greening the industry;
3. food security and safety for Europe and beyond;
4. a socially inclusive and healthy Europe; and
5. The Ocean of Tomorrow.[19]

The 2011 annual work programme document included a section on "the innovation dimension" and the allocation of 15-25% funding to SMEs was required in many individual projects. The rationale for this requirement in terms of economic or social impact is not set out in the programme documents, a point noted by an expert evaluation document on SME participation in FP7.[20] The requirement of SME participation may have two drivers, the 'small is beautiful'[21], or the inclusion of end users and industry in the uptake of research results. A rationale for SME participation was set out in the 2012 work programme.

The introduction to the 2012 work programme reflected the concerns arising from the economic problems following the 2008 financial crisis mentioning economic growth and employment. The Innovation Union was introduced as a driver and the work programme responded to the conclusions of the European Council of 4 February 2011 concerning the crucial role of SMEs in translating research into market applications. Distinct development and demonstration projects were introduced.

The final call work programme in 2013 introduced the European Innovation Partnership (in agriculture) and reinforced the innovation and economic growth agenda introduced in 2011 and 2012.

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[19] This is a cross-thematic cooperation. The programme was actually launched in 2010 during which year three projects were funded

http://ec.europa.eu/research/bioeconomy/fish/research/ocean/fp7-ocean-projects_en.htm

[20] Panteia 2014. Performance of SMEs within FP7: an interim evaluation of FP7 components, Volume I http://ec.europa.eu/research/sme-techweb/pdf/volume_i_smes_in_fp7-may2014.pdf

[21] "Think Small First" A "Small Business Act" for Europe, COM(2008) 394 final, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0394:FIN:EN:PDF

3.6 Objectives and coverage of topics in annual work programmes

Here we describe the content of the research as planned. An assessment of the relevance of it to the drivers is presented in section 3.6.

The programme was broad in several respects. As discussed above, it includes activity that borders on pure biological research at one end (Enabling research, area 1.1) through to development and demonstration activities at the other. It covers all the major sectors of food, fisheries, aquaculture, bio-based industries, agriculture and forestry, and includes Europe's investment in animal health and welfare research, which has practical impact well beyond farming.

Generally, the type of research (basic to applied) and the relevance to broad user groups remained relatively stable over the seven years. On the basis of the compilation of individual project calls and resulting projects, a number of trends are identified.

The topics in the seven work programmes are described below in relation to the administrative sub-programmes (areas) that the EC used.

3.6.1 Food

In the food activity, two periods can be distinguished. In the first period, the focus was on food choices and their role in dietary disorders such as obesity and food intolerance, with an emphasis on strategic research approaches. Topics with particularly high science impact potential related to food processing and the food chain were included in these earlier calls. In later calls, the emphasis was more on supporting technical innovation, particularly in the food processing area. There was more emphasis on "market pull". A stronger involvement of industry, policy makers and others stakeholders such as consumers associations, standardisation and legislation organisations and Professional Associations was evident. The food research in the five areas covered the following:

Area 2.1 **Consumers:** Understanding consumer behaviour and consumer preferences as a major factor in the competitiveness of the food industry and the impact of food on the health and well-being of the European citizen. The focus was on consumer perception and attitudes towards food including traditional food, understanding societal trends, and identifying determinants of food choice and consumer access to food. The research included the development of databases on food and nutrition research.

Area 2.2 **Nutrition:** Understanding beneficial and harmful dietary factors as well as the specific needs and habits of population groups as a major controllable factor in the development and reduction of occurrence of diet-related diseases and disorders including obesity and allergies. This involved the investigation of new dietary strategies, the development and application of nutrigenomics and systems biology, and the study of the interactions between nutrition, physiological and psychological functions. It could lead to reformulation of processed foods, and development of novel foods and ingredients, dietetic foods and foods with nutritional and health claims. The investigation of traditional, local, and seasonal foods and diets will also be important to highlight the impact of certain foods and diets on health, and to develop integrated food guidance.

Area 2.3 **Food processing:** Optimising innovation in the European food industry through the integration of advanced technologies into traditional food production including fermented food, tailored process technologies to enhance the functionality, quality and nutritional value of food including organoleptic aspects in food production including new foodstuffs. Development and demonstration of high-tech, eco-efficient processing and packaging systems, smart control applications and more efficient valorisation and management of by-products, wastes, water and energy. Research also on developing sustainable and novel technologies for animal feed, including safe feed processing formulations and for feed quality control.

Area 2.4 Food quality and safety: Assuring chemical and microbiological safety and improving quality in the European food supply for understanding the links between microbial ecology and food safety; developing methods and models for addressing the integrity of the food supply chains; new detection methods, traceability and its further development, technologies and tools for risk assessment, including emerging risks, management, and communication, as well as enhancing the understanding of risk perception.

Area 2.5 Environmental impacts and total food chain: Protecting both human health and the environment through a better understanding of the environmental impacts on and of food/feed chains. This involved the study of food contaminants and health outcomes, monitoring of environmental effects, developing enhanced tools and methods for the assessment and management of impacts of food and feed chains on the environment. Assuring quality and the integrity of the food chain requires new models for commodity chain analysis and total food chain management concepts, including consumer aspects.

3.6.2 Agriculture

There was a progressive increase in emphasis on research relevant to commercial innovation and market applications expressed in annual work programmes. However, in general, and with the exception of a reduction in animal health research, this did not result in a marked change in the type of agricultural research over the seven years. This is largely due to the intrinsic relevance of agricultural research to farm practice and business. The research was managed in four 'areas'. (Table 1):

- enabling research;
- increased sustainability of all production systems; plant health and crop protection;
- animal health and welfare; and
- socio-economic and policy research.

These 'areas' are not a clear guide to the content of the research. In several of our case studies, closely related projects with common targets was funded from several of these areas.

The emphasis on the sustainable development of farming and forestry remained throughout with increasing support for international research (i.e. collaboration outside the EU), particularly in the 2010 call. There was a concerted effort to build capacity in strategic research relevant to forestry and genetic improvement generally through 'enabling research'. The use of biotechnology approaches is a characteristic of agriculture research in FP7.

The enabling research (1.1) was expected to provide a stepping-stone between fundamental biological knowledge and its application at a strategic level. These potential applications include the use of molecular biology in plant breeding, the exploitation of biodiversity and of novel bioactive molecules, genomics, proteomics, metabolomics. Systems biology and molecular biology enabled by biotechnological approaches are core disciplines in this research. A significant proportion of this research had a strong fundamental or speculative character and is far from exploitation.

Core disciplines in research on **sustainable production (1.2)** include molecular biology, biotechnology and modelling as well as the full range of agricultural and environmental sciences. The target applications include plant breeding (particularly for abiotic stress and adaptation to climate change), new production technologies, monitoring systems, novel plants and improved farming and cropping systems, crop management, plant health, and soil protection. Emphasis was placed on low input production techniques (e.g. less pesticide and fertiliser use) and improved management of resources. There was a restoration of research on forestry with emphasis on ecosystem studies and research relevant to forestry policy for enhanced provision of public goods.

The animal health, welfare and production research area (1.3) aimed at using genomics to support new breeding methods, improved understanding of animal physiology and behaviour and the better understanding and control of pests, parasites and infectious animal diseases and other threats to the sustainability and security of food production, including zoonoses. New knowledge for the safe disposal of animal waste and improved management of by-products was also to be developed. Topics called for research approaches for controlling infectious diseases, development of control strategies for tuberculosis (TB), African Swine Fever, new vector-borne diseases (West Nile fever, Rift Valley Fever and Crimean-Congo haemorrhagic fever).

Particularly from 2011 onwards, there was a move away from research into animal diseases of public importance towards diseases of mainly farm economic importance such as parasitic worms (helminths). Reflecting the switch to economic targets, investment in animal health and welfare dipped in the 2012 with only three topics, and only one of these focused on health (African Swine Fever). Resistance to anti-microbial products (e.g. anibiotics) was the subject of research initiated in 2013.

The socio-economic and policy research area (1.4) was about providing the tools to support the development and implementation of policy and to meet the needs of rural development. This research also played a gap-filling and 'horizon-scanning' roll for the other areas (using biological research), and supported systems research that did not fit neatly into the other programme areas. It included research that was relevant to other activities, particularly animal and plant health. Plant breeding was supported with research involving partnership with China. The area is also the home of all research targeted specifically at the organic sector. This area also hosted specific development and demonstration projects to further the exploitation of existing research results. There was also increased emphasis on international collaboration from 2008 onwards.

Research for all policies, including the Common Agricultural Policy, was to include socio-economic studies and cost-benefit analysis, comparative investigations of different farming systems including multifunctional ones, the rearing of non-food animals, interactions with forestry and studies to improve rural and coastal livelihoods. Some of the research has specific policy mechanisms in mind such as research to develop a common data exchange system for agricultural systems and modelling based on the Farm Accountancy Data Network; transition pathways to sustainable agriculture; farming-related knowledge systems for sustainable rural development.

3.6.3 Fisheries and aquaculture

The fisheries and aquaculture research addressed ecosystem as well as socioeconomic objectives. Most of this research was embedded in area 1.2 along with the production agriculture research. This research included consideration of some specific issues such as a bottom-up approach to governance, stakeholder engagement, uncertainty in stock assessments, fishery impacts on ecosystems, climate change, fleet overcapacity, discards policies as well as socio-economic impacts deriving from the implementation of the new conservation measures.

In aquaculture, the main challenge was increasing production while meeting environmental, social and economic goals. The research covered generation of basic knowledge in the biology and lifecycle of established and new aquaculture specie; using biomolecular tools; establishing greater control of reproduction and the lifecycle; development of tailored solutions for optimised feed conversion to high quality products; and providing science-based recommendations for further development of the EU regulatory framework and for underpinning future growth of the sector.

Fishing and aquaculture activities compete for coastal space and are in interaction with the marine environment. Spatial planning, exploitation of mutual opportunities for development and vigilant monitoring of the aquatic environment at a sentinel level are crucial to European marine and maritime economic sectors.

3.6.4 Biotechnology

Not all areas of the programme started together and there was a shift in the later years towards industrial and biorefinery projects and product development away from research on novel sources of biomass. In the industrial biotechnology research, the focus moved from the source of a product towards production processes, for example to research on multistep biocatalytic engineering. The range of these process-related activities was balanced to some extent by the incorporation of more research related to end-products. Some projects on novel sources e.g., EUPEARLS produced results that led to further projects on industrial biotechnology (DRIVE4EU).

In the area of marine and freshwater biotechnology, there was a clear evolution of the programme from a focus on organisms (e.g. MAMBA and MAREX projects, screening programs, metagenomics) towards product development (e.g. BLUEGENETICS, RADAR) and integrated processes (MIRACLES, D FACTORY). Metagenomics was widely used in organism-based research. In parallel, production platforms were developed (SUNBIOPATH, BAMBOO, MACUMBA). Two projects resulting from 2013 work programme addressed complete value chains (D FACTORY, MIRACLES). The MIRACLES project might have a special impact since it is the only project in marine biotechnology to involve large industrial companies.

For the environment and emerging trends areas, there was an increase in the allocated budget over the seven annual work programmes. The environmental biotechnology research was strongly focused on the application of research results towards environmentally-friendly products and processes as well as on support of general policies, decision making and standardisation. The comparatively strong increase in the funding for research on emerging trends runs counter to the overall goal of fostering the application and exploitation of biotechnology towards marketable products.

In general, there has been a linear approach within projects towards the development of applications or products (also observed in agriculture). Different parts of the value chain have different challenges. Development along the different parts of the novel bioeconomy value chains might be better supported at programme level rather than within projects. This would better support more integration and synergy between complementary research efforts. The linear approach taken in the research can miss some of the potential synergies that may exist between different research areas.

3.6.5 Horizontal aspects

The Horizontal aspects of the programme were focussed on improving capacity and capability in, for example, key agents such as National Contact Points and in sharing best practice between them across the Member States and with non-MS countries. Internationalisation, through international collaboration, was a priority.

A major cohering aspect was cross-cutting efforts to support the development of the ERA enabling transnational research and innovation by encouraging international collaborations between researchers on the one hand and by exploiting synergies between national and international programmes, strategically aligning different sources of national and other funds at EU level.

3.7 Strategic effectiveness of the programme

Here we provide our assessment of how well the programme as planned (3.4 and 3.5) matches the drivers and challenges behind it (3.2 and 3.3).

3.7.1 Alignment to challenges

Our assessment is that the agricultural, fisheries and aquaculture research and part of the biotechnology activity in FAFB serves Europe 2020, particularly the flagship initiatives 'Innovation Union' and 'Resource efficient Europe', well through the direct relevance to primary resources. Resource capture and resource use in production systems, complementing the focus of the food programme (Fork to farm: Food health and well-being), accounted for 48% of funding. Resource management, efficiency and protection can be regarded as a unifying theme of the agriculture, fisheries and aquaculture, and some biotechnology research and therefore matches the thinking set out in the 3rd SCAR Foresight Report[22] and a wide range of EU and external drivers described 3.2 and 3.3. There is particularly high relevance to 'Resource efficient Europe' which emphasises a significant transition in agriculture and alignment of the CAP to a low carbon economy.

It must be recognised that this degree of alignment with Europe 2020 is not the result of planning for that purpose, not least because much of the research in FP7 pre-dates Europe 2020. From the start, the annual work programmes were significantly influenced by the European Technology Platforms and the work of SCAR and in many respects the range of projects are a strong indication that programme managers used the TPs (from FP6) well. We conclude therefore that at this relatively high level, this programme was markedly better suited to the Europe 2020 Strategy than its predecessor.

In food, it is striking how often the FP7 projects have referred to the priorities in the Strategic Research Agenda of the ETP Food for Life as important driving forces and motivations for their projects. A positive example of ETPs influencing FP7 programming is the case of animal health and welfare (AHW) related research. The first external evaluation of the Community Animal Health Policy (CAHP) took place in 2005 and 2006 and the final report[23] (2006) provided a basis for the new Animal Health Strategy for the European Union (2007-2013) which included the principle "Prevention is better than cure".[24] Research became a pillar of the strategy (4. pillar). Several tools were put in place to allow the Strategy to improve the activities in this area: the network of National Reference Laboratories, the European Agencies on scientific risk assessment and the new FP7.[25] By this time, the programming of FP7 was already at the final stage. However, the Animal Health Strategic Research Agenda (SRA) provided by the European Technology Platform for Global Animal Health (ETPGAH) in cooperation with Collaborative Working Group on European Animal Health & Welfare Research in SCAR was already completed to inform the development of topics. The SRA recommendations clearly appeared as research drivers and priorities throughout the FP7 programme.

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[22] SCAR 2011. Sustainable food consumption and productin in a resource-constrained world. 3rd SCAR Foresight Exercise.

[23] The "Evaluation of the CAHP: Final Report" (2006)is available at http://ec.europa.eu/food/animal/diseases/strategy/archives/final_report_en.htm.

[24] A new Animal Health Strategy for the European Union (2007-2013) where "Prevention is better than cure" Luxembourg: Office for Official Publications of the European Communities, 2007.

[25] ANIHWA deliverable:D2.5: Identification of research drivers emerging from the drafting of the new Animal Health Law and other EU actions.

In our examination of agricultural projects clustered according to their impact areas, we notice some cases of the programme addressing some themes quite late. For example, research relevant specifically to dairy cow genetics and 'robustness' was introduced in 2007 even though there have been growing concerns about the sustainability of dairy cow breeding and management with increasing use of very high yielding Holstein strains since about 1980. Another example is the establishment of two 'enabling research' projects in precision production technologies in 2012. While we have no reason to doubt that these research projects were at the cutting edge of their fields at the time, it is noteworthy that much of this was initiated well after these challenges and opportunities were recognised in the respective research and innovator communities, as shown by preceding national projects. Some of this late engagement with challenges is probably due to the de-prioritisation of production agriculture in FP6.

Fisheries and aquaculture projects contributed to the flagship "*Innovation Union*" of "*Smart growth*", promoting technological achievements and particular projects were realised with a high SME involvement. Towards the end of the programme a series projects were explicitly designed to transfer knowledge to the industry (e.g. TRANSDOTT) and support "Innovation Union" and generate technological achievements (e.g. MARIABOX).

"*Sustainable growth*" was the main focus of fisheries and aquaculture projects. The flagship "*A resource-efficient Europe*" was addressed very well by all fisheries and aquaculture projects that generate new basic and applicable knowledge towards the efficient use of existing and new resources and the protection of the environment. In addition, fisheries and aquaculture projects made significant contributions to the flagship "*Industrial policy for globalisation era*", supporting the strength, diversity and competitiveness of fisheries and aquaculture industries and the consumers towards well informed choices.

With respect to "*Inclusive growth*" some fisheries and aquaculture projects aimed to support economic activities in areas with little and low-paid job opportunities, where poverty indices usually lie below average. In this broader sense, this research indirectly serves the flagships "*Agenda for new skills and jobs*" and "*European platform against poverty*".

We found it difficult to identify a clear rationale for the approach to research supporting the bio-based sector in the biotechnology activity and a number of strategic weaknesses were identified. This observation does not question the merit of the research projects. The biotechnology research seeks to contribute to the following priorities: growth and jobs (through novel industrial applications from improved crops, novel biomass sources, and novel production methods for new tools) and improved climate change mitigation and adaptation (mitigation through reduced emissions with sustainable novel biomass sources, adaptation through stress tolerant crops). For marine and freshwater biotechnology, priorities were in accordance with EU Marine and Maritime policies on economic (blue growth policy, http://ec.europa.eu/maritimeaffairs/policy/blue_growth/index_en.htm), and environmental sustainability, as well as with the strategy papers of the ESF and the OECD on marine biotechnology. In general the aims of biotechnology activity would contribute to a resource efficient Europe and thus support the above agenda. Going forward there is a clear need to focus biotechnology development on those areas where the EU can compete on the world stage.

3.7.2 Strategic programming

In seeking to understand the alignment of the programme to drivers and challenges, and identify the rationale behind activities and areas, we have observed a research strategy and management gap between the high-level socio-political objectives defined at FAFB programme level on one hand and the individual topic (project) call scientific objectives on the other. This was particularly evident in agriculture and fisheries (which were combined in activity 1 (sustainable production and management of biological resources from land, forest and aquatic environments). The societal goals are broad strategic social, environmental and economic goals, while the individual project calls set out required project outputs and outcomes in varying degrees of detail and specificity. With the exception of brief descriptions of the types of research that might be relevant in each area, there is a lack of a science-based operational framework or research strategy systematically connecting the societal goals and the required science and technology outcomes. The agriculture case studies showed that research relevant to target user groups and problem areas was in several cases funded from several programme areas, sometimes as many as three. This indicates that efforts to target resources and to foster synergies do not have the benefit of a strategic science-based research programming framework.

There is no process evident in public documents that systematically turns societal goals into coherent agreed research targets (science and technology outcomes) that are pursued in a flexible and dynamic way at a level above individual projects. An example is research on the improvement of dairy production. Here, about €30 million was invested in six projects that all deliver impact in the context of Europe 2020 through technical change on dairy farms and through livestock breeding companies supporting dairy farms. The research as a whole was not planned by the EC to address these targets. Of the six projects, only two (REDNEX and SOLID) arose from a call that specified research on dairy cattle. The other four projects arose from topic calls that provided more general research funding opportunities: breeding tools for livestock products (ROBUSTMILK), optimised farm animal reproduction (FECUND and PROLIFIC), and development and exploitation of genomic data and tools (GplusE). It could be said that the EC responded to research opportunities offered by the research community and the result over the seven years is a cluster of projects funded from three different 'areas' that happen to be relevant to this well-recognised agricultural challenge.

This lack of a science-based operational framework is also clearly evident in the very diverse range of research projects supported under the biotechnology activity. The projects themselves were successful but the lack of definition or analysis of market opportunities and a structured approach to meet such opportunities meant that projects individually took a linear approach to separate product chains rather than a more holistic approach which would have created better synergies across a more clearly defined area. This linear approach also led to overlap between calls with similar research funded in different projects. For example, the overlap between marine biotechnologies and fisheries (e.g. in sensor development and uses of microalgae, and between research on novel sources and research on biorefinaries.

The lack of an explicit science-based programming framework for the FAFB programme generally also has implications for the transparency of decisions. The annual work programmes announce funding allocations to projects and areas. The 'context' sections are largely descriptive and do not explain these funding allocations, the relative magnitude of which changed significantly over time (Figure 2 and section 3.7). The use of a science-based programming framework would facilitate a clearer presentation of changes in research targets and the funding of them.

The lack of clear and visible programming was compensated using internal mechanisms operated by the EC staff. This was particularly evident in the animal health and welfare research, and in fisheries and aquaculture. A report by the European Commission[26] observes that EU funded research projects have made major contributions to European policies for animal health with a comprehensive portfolio in relation to policy needs. Over many years, animal health research has been characterised by the anticipation of research needs in advance of these becoming clear in policy circles. This is a major achievement and demonstrates the benefit of long-term strategic portfolio management and the foresight used to identify future research needs and to ensure continuity of research. This is a remarkable achievement given that the programme as a whole does not explicitly provide a supporting programming framework. Similarly, in fisheries and aquaculture, EC staff developed and worked to the six priorities set out in section 2.3.

[26] European Commission 2012. A decade of EU-funded animal health research. Publications Office of the European Union 213 pp. ISBN 978-92-79-21035-8

3.8 Effectiveness of resourcing (distribution of funding)

3.8.1 Distribution of funding

The overall budget was €1.9 billion. This represents an annual increase of 46% over the corresponding research in FP6. The allocations to the thematic areas were as follows: biotechnology 32%, agriculture 31%, food 27%, fisheries and aquaculture 9%. The horizontal activity accounted for 0.5% (Table 1). The changes in allocations to thematic areas over the seven annual work programmes is shown in Figure 1. The corresponding project numbers are shown in Figure 2.

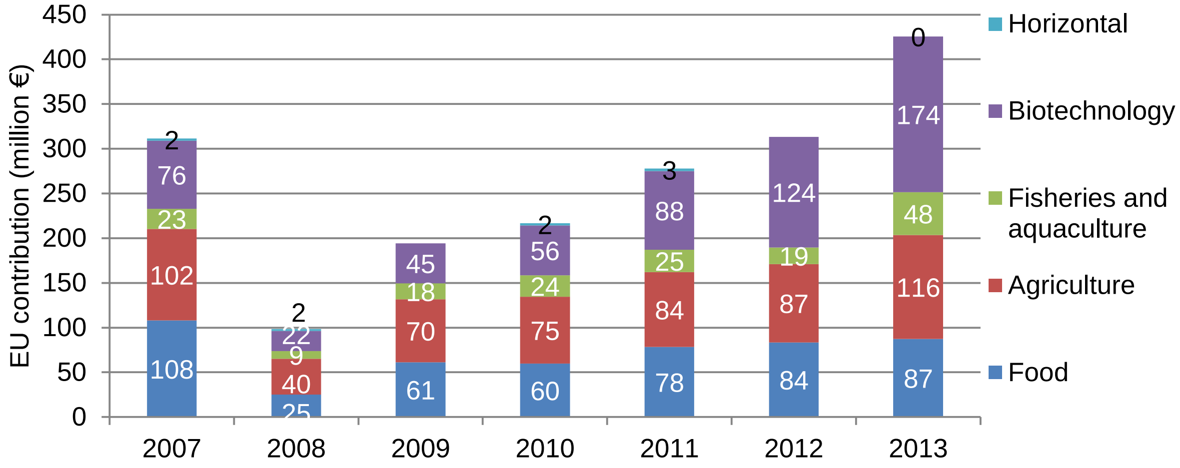

Figure 1. The distribution of funding to projects in the four thematic areas and horizontal activities arising from the seven annual work programmes.

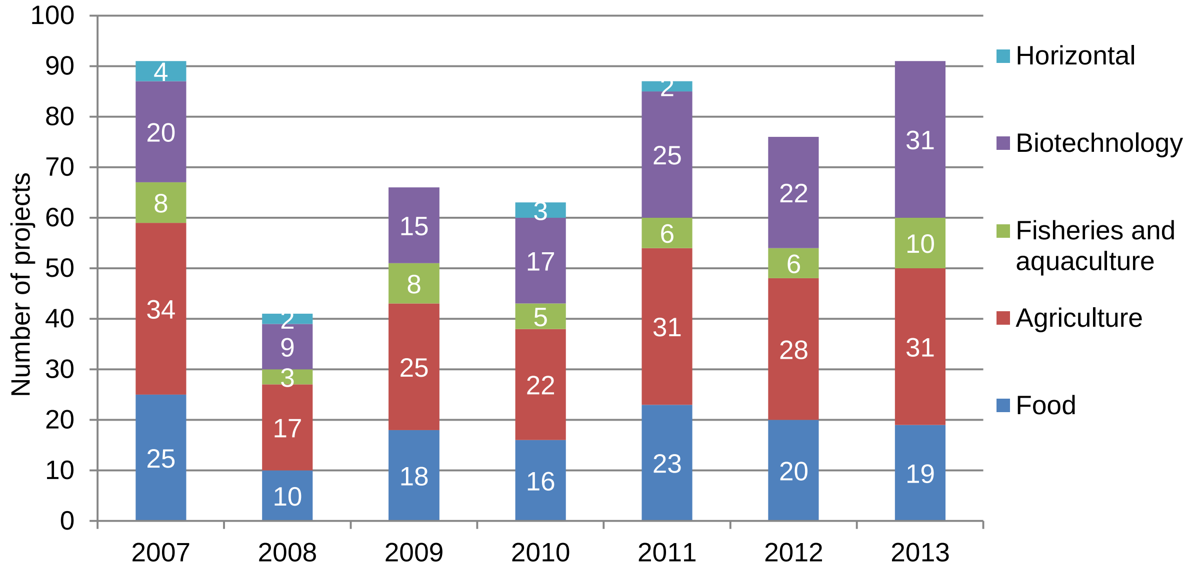

Figure 2. The number of projects in the four thematic areas and horizontal activities arising from each of the seven annual work programmes.

Food: In total the funding of food projects during the seven years of FP7 was €504 million. The level of funding in annual work programmes remained relatively stable across the seven work programmes but declined as a proportion of funding from 35% in 2007 to 20% in 2013.

Agriculture: Funding for collaborative 'agricultural' research increased from €333 million in FP6 to €574 million in FP7 (31% of the FAFB funding). On an annual basis this was a 23% increase in cash terms (FP6 to FP7). As with food, the funding was relatively stable in absolute terms over the seven work programmes (allowing for the general drop in 2008), but as a proportion of total funding it declined from 33% in 2007 to 27% in 2013. It is comparable in research funding terms to just one of many national agricultural research programmes operated by Member State ministries of agriculture. The farming component equates to about 40 cents per hectare per year for the agriculture area of the European Union, and the forest component 5 cent per hectare per year for the forest area. This is a central but not dominant position complementing national agricultural research programmes and the basic or strategic research funded by the ERC and national research councils. This means that strategic targeting in relation to goals is particularly important if the purpose is to provide leadership in this research funding landscape.

Looking at the allocations to specific areas of impact, there are some substantial investments. For example, the investment in agricultural research that delivers impact through improved plant breeding is substantial at about €93 million making it potentially a important strategic resource at European level. The same applies to the corresponding investment in animal breeding where about €50 million was invested. This investment in the genetic improvement is closely linked to further a large investment (€91 million) in 'enabling' research, mostly basic and strategic bioscience research.

Against the background of a 72% increase in funding for 'agricultural' research (from FP6 to FP7), the investment in animal science focused on public policy and public goods (surveillance, animal welfare, and zoonoses/notifiable diseases) fell from €101 million in FP6 to €67 million in FP7. Investment in animal research focused on production and associated environment-related targets nearly doubled from €57 million in FP6 to €113 million in FP7 against a general increase in animal science research of 15%. These changes between FP6 and FP7 were mainly the result of changes in FP7 made from 2011 onwards.

In contrast to these continuing large investments in scientific research, investment in dedicated development and demonstration activities is modest at €8 million in 8 projects arising from 5 call topics. Five of these arise from two calls in 2012 and 2013 specifically for this purpose. There was also increased investment in research strategy development (€3.7 million in FP6 to 13.0 in FP7). This is an area where further research could bring rewards, particularly if it were to support more active strategic programme leadership by supporting path-finding, horizon-scanning and scoping research.

Fisheries and aquaculture: The total EU contribution to projects in the fisheries and aquaculture area funded from FAFB reached €165 million. Allocations in annual work programmes increased significantly between 2011 and 2013 (Figure 2) to cover spending on more technological developments and become attractive to high-tech SMEs, and due to research in the Ocean of Tomorrow initiative (€24 million). Due largely to the Ocean of Tomorrow initiative, the investment in fisheries and aquaculture research increased from 7% of total FAFB funding in 2007 to 11% in 2013.

Half of the EU contribution was allocated in building the knowledge-base for EAFM (€50 million) and understanding the essential biological functions of farmed aquatic animals to support a sustainable aquaculture (€54 million). A considerable proportion of the EU contribution was devoted to the investigation of the socioeconomic dimension of EU fisheries and aquaculture industries (€10 million) and new governance for the implementation of the CFP and its integration in the EU IMP (€39 million). Technology transfer and translation of aquaculture research into application attracted only a fraction of the budget (€3.8 million).

Biotechnology: The main activity areas had similar budget allocations. Primary production and novel sources of biomass and marine and fresh-water biotechnology received over €200 million. Research on biorefinery and industrial biotechnology, which emphasize the middle and end parts of the value chains, received together close to €200 million. The more cross-cutting research on policies, emerging trends and environmental technology received together around €150 million. These research areas overlap, but clearly all parts of the bio-based industries value chains have been addressed. The biotechnology area grew very substantially over the life of the programme. Allocated funding more than doubled in absolute terms and increased from 24% of FAFB funding in 2007-2008 to 41% in 2012-2013.

3.8.2 Adequacy of funding

The description above still leaves the question of the adequacy and distribution of funding. Have the funds been sufficiently and optimally distributed in relation to the objectives of FP7? The answer to this question can only be suggested by expert judgement which is subjective since the programme documentation (e.g. annual work programmes) provides little insight into a funding framework or the rationale for allocation of funding in terms of science content and target impacts. There is no discussion about market failure for the respective research fields and for example the risk that the programme might displace private sector investment, or leave gaps not filled by the private sector or national funding.

In agriculture, we examined the changes in funding allocation between FP6 and FP7 in terms of target impact areas and concluded that the changes in the distribution of funding within that thematic area compared with the corresponding research in FP6 was appropriate. However, the lack of explicit and published strategic planning behind these changes, particularly with regard reductions in funding for animal health research from 2011 onwards, is notable.

Considering the much larger resource invested by member states, this level of funding can strengthen the scientific and technological base best where it is targeted to complement or lever the much larger resource invested at national and regional level or used to prime new research opportunities.

3.9 Research integration

We were asked to consider two particular aspects of the nature of the research approaches supported: the position on the scale basic to applied, and the pluri-disciplinarity of the research and how well systems challenges are addressed.

3.9.1 Portfolio profile: basic vs applied research

For all thematic areas it is clear to us that both basic and applied, integrated holistic research is needed, which addresses demands from social and economic aspects of everyday life. We were thus asked to assess the profile of the portfolio in terms of basic and applied research.

The stages on this spectrum are open to interpretation. If the Frascati definition of basic vs. applied research is used (basic research is experimental or theoretical work undertaken primarily to acquire new fundamental knowledge without any particular application or use in view), then all the FAFB research is or should be applied research (applied research is original investigation undertaken in order to acquire new knowledge directed primarily towards a specific practical aim or objective).

Some of the work in the programme aligns with the Frascati definition of experimental development (experimental development is systematic work directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed). Calvert and Martin[27] describe the concept of strategic research. Strategic research is long-term research that is more directed than 'pure or curiosity oriented' research.

We estimate that there is a relatively even spread of resources across the strategic and applied types of research flanked by examples of basic research or experimental development.

Overall, considering that this is goal-oriented research we do not believe that the research is too applied. A large proportion of the agriculture research is classified as 'enabling' (16% of total funds in agriculture) which is at the basic end of the spectrum. In addition a substantial proportion of the research in 'sustainable primary production' (agriculture) is strategic (e.g. DROPS). Several of the call topics in this area of agriculture specified strategic research, particularly the use of 'omics' and other biotechnology approaches. With the exception of enabling research and research on the biology of aquaculture species, the topics generally implicitly require the use of applied approaches, for example in the development of vaccines. Fisheries research was applied, except for some research on the biology of some species and the development of Bayesian statistical methods which might be theoretically or strategically interesting (including outside fisheries). All other result supported more effective fisheries management.

In biotechnology, no true basic research is involved but this distinction between basic research, applied research and development has become blurred. Some projects were focused on technology and thus could be said to have a more basic leaning. Thus in the novel sources biotechnology research, there was more evidence of basic research than in the industrial area. For example the EUPERLS project was more focussed on how to produce the plants to provide alternative sources of rubber than the use of the rubber whereas the DRIVE4U project funded later in the industrial area focussed much more on using the rubber. In general most emerging trends research had its main focus on basic research questions esp. SYSINBIO and DINAMO. Environment biotechnology was more focused on application and support of decision making/standardisation esp. WATERBIOTECH or GREENLAND

The use of dedicated development and demonstration projects was an innovation in agricultural and aquaculture research in the 2012 and 2013 work programmes, but accounts for a relatively small proportion of activities in funding terms.

3.9.2 Pluri-disciplinary and systems research

Pluri-discplinarity is a strong feature of the research which is in line with the legal basis of the Framework Programme.[28] Collaboration between researchers in different scientific fields is a feature of all the research we examined but this is not especially a feature of 'systems' research, as is implied by the Terms of Reference for our work. We understand systems research in this context to mean studies into the performance and functioning of agricultural, fisheries, forestry production systems and related systems in food and non-food processing. Systems research focuses on the interactions between connected components rather than on the components themselves. Some systems research may use relatively few disciplines, for example research that uses life-cycle assessment or economic modelling.

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[27] Calvert and Martin 2001. Changing conceptions of basic research? Background document for the workshop on policy relevance and measurement of basic research. Oslo 29-30 October 2001.

[28] COUNCIL DECISION of 19 December 2006 concerning the Specific Programme "Cooperation" implementing the Seventh Framework Programme of the European Community for research,

Pluri-disciplinarity is not an end in itself, but some of the topics indicate that it might be regarded in this way. Some of the topics demanded a wide range of different research activities. We identified a significant number of topics that expand the requirements in several directions leading to the inclusion of a large number of disciplines in projects. The orientation of research, even strategic research, along specific supply chains within projects was noted in both the agriculture and biotechnology thematic areas.

In the food area, few projects systematically drew on the social science disciplines. Instead of adopting Science, Technology and Society (STS) thinking to examine the relationships between scientific and technological innovations and society, the familiar public debate about some aspects of biotechnology, environmental sustainability and information technology, the social science –related effort tended to be regarded as a need for 'consumer education', rather than as evidence of a misalignment of values and understanding in both directions. Furthermore, much of the social science in the projects focuses on understanding and changing individual thinking and practice. Society wide issues or aspects of food equality and inequality have much less of a presence. Policy, which is central to efficient commercialisation of research outputs appeared to be under-represented in the portfolio.

The agricultural research covered a very wide range of disciplines, many integrated at the project level. 'Enabling' research (Area 1.1) was heavily focused on 'omics' and the development of biotechnology approaches. The biosciences also dominate the sustainable primary production research (Area 1.2) and animal health and production (Area 1.3). Despite the prominence of the biosciences, collaboration between agricultural economists, social scientists, policy specialists and agricultural biologists is common in the research aimed at the sustainable development of production.

Research aimed at animal health, particularly notifiable diseases, is at first sight less multi-disciplinary. However, in terms of the challenges presented, the research is characterised by openness to the engagement of the full range of disciplines required. The collaboration between molecular biologist, epidemiologists, immunologist, pathologists, veterinary and human medicine experts, ecologists, mathematicians and spatial data analysis experts was quite common in the consortia. We note however a lack of involvement of economists and social scientists in animal health and welfare research. Research relevant to the development of public policy was characterised by collaboration between policy specialists, economists, and environmental scientists.

Aquaculture research is characterised by reliance on one or few disciplines. In contrast, fisheries research was more inter-disciplinary involving biology, environmental sciences, fisheries science, economics, social sciences, law, mathematics, computer science, trainers and communication experts. In addition, expertise from the industry provided by SME participants enriched studies. Social scientists were sometimes included; nevertheless, biologists and economists sometimes dealt with disciplines such as social science for which they were not formally trained.

The Ocean of Tomorrow call topics were designed to have a high technological impact by bringing together different scientific disciplines to deliver sustainable solutions for marine and maritime activities and achieved a high engagement of SMEs that are active technology developers.

The biotechnology research supported multi-disciplinary teams were supported in projects. With the exception of two projects in the industrial biotechnology area, all projects contained at least 6 partners of a multidisciplinary nature and half the projects had more than 10 partners. In industrial biotechnology, the emphasis varied greatly with some projects heavily weighted towards a particular part of the process whereas others drew together teams more balanced over the whole production chain. For marine and freshwater it is important to note that large companies (main industrial players) are only involved in 2 projects. This reflects the current problem in marine biotechnology: the critical mass for developing and marketing new products is still far too low. This development cannot be done with just SMEs.

In emerging technologies (biotechnology), expertise from many fields were brought together. In novel sources research, inter-disciplinarity typically meant, for example, bringing together of novel research on biomass producing plants and organisms and sectors utilizing, refining and upgrading the biomass. Research in biotechnology on crop breeding and development is often linked within projects to research on specific requirements from the downstream processing side. This was also a feature of crop breeding research in agriculture. Many biotechnology projects on crop genetics targeted improved crop stress tolerance, and in these projects inter-disciplinary teams were achieved through mixing of different fields of science, such as biology, chemistry, computational modelling, environmental impact assessment and economics.

With the exception of two projects in the industrial biotechnology, all biotechnology projects contained at least 6 partners of a multidisciplinary nature and half the projects had greater than 10 partners. In industrial biotechnology the emphasis varied greatly between projects with some projects heavily weighted towards a particular part of the process whereas others drew together teams more balanced over the whole production chain. For marine and freshwater it is important to note that large companies (main industrial players) are only involved in 2 projects. This reflects the current problem in marine biotechnology: the critical mass for developing and marketing new products is still far too low. This cannot be done with just SMEs.

3.9.3 Mainstreaming of biotechnology

In FP7, modern biotechnology became a mainstream research tool. Of the 515 projects 139 are in the biotechnology thematic area. Of the 384 remaining, 8 mention biotechnology in the abstract, 37 use genomics, and 61 use the word 'genetic'. In the agriculture thematic area 36 of 188 projects used life science technology such as genomics and biotechnology. In fisheries and aquaculture only 2 of 53 projects use biotechnology as a tool. The equivalent figure for food is 3 out of 132 projects using biotechnology.

4 Implementation

4.1.1 Promotion of the programme

The Framework Programmes are well known in the European research community, and the profiles of research teams indicate that it has been successful in attracting and integrating leading researchers. EC promotion material was not just general, but included material aimed at specific parts of the FAFB user community. For example, The Ocean of Tomorrow was the new element of the FAFB programme that was promoted in a series of information days organised annually between 2010-2013 and the first conference “The Ocean of Tomorrow projects: what results so far?” took place in Brussels in March 2014.

Technology Platforms have been useful with respect to promotion. Scientific societies have given special attention to the presentation of FP7 results, where EC staff members have been invited to promote the FP7 programme. The EC have also worked very closely with the National Contact Points (NCPs) for the promotion and the implementation of the programme.

We conclude that the programme was adequately promoted, including in Third Countries. This conclusion is supported by the competitiveness (attractiveness) of the programme which we discuss later.

It is easy to assume that programme promotion is a good thing overlooking the costs. In terms of securing wide recognition of the programme, the centralising of some publicity activities (e.g. project websites, using a centralised content management system; a public and standardised project reporting system) might be an effective way of raising the profile of the programme by focusing on its outputs. This approach is also synergistic with other goals such as the systematic dissemination of the programme and securing a coherent record of the research activities.

4.1.2 The development and implementation of calls

In terms of quality of process, the calls were developed well and processed effectively. Time to Grant (TtG: time between closing of calls and the start of the projects) has in most cases decreased. The independent assessments of the implementation processes that we received all reflect positively on the fairness of the processes and the competence and integrity of Commission staff.[29] [30] There is much less evidence of assessment of the quality of the assessments selection panels make. Very few appeals were successful and we note that these appeals are assessed internally within the Commission.

The work of developing each annual work programmes began at least a year in advance of the official publication of the call. Once published, the official competition phase lasts about 4 months. For biotechnology, this is thought to be a too short a time period for the development of proposals, considering the great effort required to plan international collaboration. There was typically 10 – 12 months between the close of the competition to the commencement of the research. This means that the overall lead-in time to the start of research activity is about two years.

The evidence made available to us did not describe the processes of developing call topic texts. We can only comment from indirect evidence and our experience as experts. The development of calls for research appears to have had a strong ‘bottom-up’ character and is

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[29] European Commission DG RTD 2009. Survey among evaluators on proposals evaluations.

[30] European Commission 2007. Interim Evaluation of the 7th Framework Programme, Stakeholder consultation.

highly focused on individual topics (projects). Some stakeholders, for example those represented by ETPs, had significant influence on the detail of call topics. Some ETPs, for example 'Plants for the future' and EATiP, include academic members and this may have contributed support for basic and strategic research to deepen the understanding of essential biological functions of farmed plant and animal species. As a result, some of the agricultural research in particular is highly focused on impacts on science.

In the preparation of topics, there is always the risk that consulted stakeholders add rather than edit requirements, or approach the consultation exercises from a sectoral position. Responding to the suggestions of target stakeholders is of course positive, but it does require interpretation of the needs expressed and articulation of their positions into coherent research targets identified to advance key goals. The absence of a science-based strategic research programming framework makes this difficult.

Proposals were long (commonly more than 80 pages) and complex documents. The high quality of the DoWs derived from them is indicative of a very thorough research planning process undertaken by applicants and the EC staff setting up the research contracts.

Proposal evaluation criteria are clear. For the criterion 'impact', the proposal form and the evaluation criteria for conventional collaborative projects and coordinated strategic actions focused on the "Appropriateness of measures for the dissemination and/or exploitation of project results, and management of intellectual property". This suggests a rather conventional 'end-of-pipe' approach to conveying research results to users who in turn generate impact. This may have contributed to the rather passive role of SMEs in much of the research from an impact viewpoint (discussed later).

One of the assumptions implicit in some calls is that relevance to users and downstream impact can be enhanced by integrating supply chain questions and actors at the project level. This was noted in particular in agriculture and biotechnology activities where research within projects examined supply-chains in a linear way. 'Participatory' approaches within projects were encouraged in some agriculture topics but much of the rationale for a participatory approach is compromised by the fact that the research targets and approaches are fixed by the DoW before the research starts and by the fact that the impact of much of the research depends on the actions of very numerous secondary users. All these additions led to complex projects and in some cases a dilution of attention to key research targets.

4.1.3 Prescriptiveness of calls

We were asked to consider if the programme moved towards less prescriptive topics to allow bottom-up approaches to deliver innovative ideas. This request seems to be founded on the assumption that less prescriptive calls are better than prescriptive calls, particularly in terms of supporting innovation.

There are a number of aspects to the question of prescriptiveness: a topic may be non-prescriptive by not defining targets (for example the species to be researched) but at the same time require a research project to cover a wide range aspects of the chosen subject. Alternatively, a topic might be specific about the main technical target but open to a wide range of solutions.

In agriculture and biotechnology in particular, there was a tendency to add ancillary requirements to the main (and often too broadly defined) goal diluting investment in the most important targets. There was an effort to develop impact by integrating research within projects along supply chain lines (e.g. research to support the improvement of legume species; research on the cultivation of marine microorganisms). An orientation on product chains within projects (which was a feature of topic calls), whether prescriptive or not, will tend to channel thinking onto specific applications over-looking innovation opportunities which would arise from a more holistic view of the research area. In addition, the combination of calls setting out a wide range of requirements, or very open research outcomes, combined with the option to recruit several projects from a topic competition, means that competition outcomes were influenced by a number of factors that applicants cannot predict, influence, or respond to. This increases the overall cost of the competition phase as the number of proposals increases and success rate declines (as was clearly observed in agriculture). There is a risk that this reinforces the dominance of a few leading research providers.

Food research topics were relatively consistent in terms of their prescriptiveness. In fisheries and aquaculture, topics did not get less prescriptive over time. The topics were generally specific and addressed very pertinent issues relevant to the objectives of the programme. However, there was in some cases a tendency for large dominating consortia to range beyond the research specified in topics. Some topics could perhaps be more efficiently addressed by smaller consortia. This would allow more consortia with proposals better focused on the objectives of the programme to compete for the funding.

In relation to the question put to us, we conclude that topics are generally not too prescriptive, and in some cases are not prescriptive enough. Prescriptiveness can be positive through bringing a focus on very pertinent issues. Non-prescriptiveness can foster 'bottom-up' ideas and is particularly relevant where opportunities for development and demonstration are offered. In food, we noted that the focus in many topics on specific needs expressed from a food chain perspective reduces opportunities for other research approaches that might be important for the ERA. In addition, these specific needs for research from a food chain perspective can reinforce existing consortia, particularly where there is one project funded per topic.

Highly prescriptive calls within a narrow field, or an area of science which requires large-scale expensive approaches (e.g. fisheries), can result in a lack of competition. In these circumstances, as observed in fisheries research, large consortia can dominate a competition.

The combination of broad and numerous general requirements, non-prescriptiveness with respect to specific research targets, ambiguity in some topic texts, and the EC's option to move flexible funds to calls that have high ranking proposals can reduce the attractiveness of calls, especially for those consortia who want to focus on core challenges. The more widespread use of the two phase process in Horizon 2020 addresses some of these issues.

Given the range of aspects to the question of call prescriptiveness, the unexplained differences between the FAFB activities and over time with respect to prescriptiveness points to a lack of a comprehensive policy or strategy for these matters. There are differences between thematic areas in terms of 'science supply push' versus strategic needs as drivers of research. We noted a strong science supply factor behind a significant proportion of the agriculture research.

4.1.4 Simplification of procedures

A number of simplification measures were undertaken, particularly in 2012. The time to grant was reduced from an average 455 days in 2008 to 386 days in 2012. The National Contact points have received these measures positively, especially the IT tools, although they point out that the improvements are slow to come into effect, and that some elements are still complex, particularly project administration procedures and financial management requirements. Evidence of effects of measures on consortia and the effectiveness of the research projects is not directly available from project documentation. There is no evidence of radical measures to change the way value-for-money is supported and how contracts are managed. The vision of EC funding based on mutual trust set out in the Lund Declaration was not realised.[31] However, the simplification measures[32] adopted by the EC for the

[31] Swedish Presidency of the European Council. 2009. The Lund Declaration. Europe must focus on the grand challenges of our time.

application of personnel costs in a manner integrated with business accountancy systems, the resolution in payments for participating in research of SME owners and natural persons without a salary, and the establishment of the Research Clearing Committee, have helped SME participants.

In agriculture thematic area case studies, we examined the budget details in project documents. These provide some insight into project administration costs. Resources declared for 'management' vary from about 3% of project costs to more than 12%. The cost of coordinating projects typically ranges from €250,000 to €600,000. Some projects attribute management costs to all partners (which would reflect reality as all partners spend time on administration), while others attribute them only to the coordinating and/or administrating partner. Tellingly, where resources for administration (as distinct from coordination) can be identified, it is common to find the equivalent of one half or more of one full-time employee allocated to contract administration.

4.2 Attractiveness of calls

4.2.1 Competition for funding

Success rates are good indicators of the degree of competition for funding. The overall success rate (i.e. the proportion of proposals funded) and trends therein are shown in Table 3. Success rates for the annual work programmes ranged from 15 to 19%. The success rate was lower in food than other areas at 13% even though the proportion of proposals passing the funding threshold was similar to FAFB as a whole. This could be a legacy of FP6 where FAFB research was dominated by the 'fork-to-farm' perspective.

In agriculture (unlike the other FAFB activities), the success rate declined significantly in 2011 from above 20% in the years 2007 to 2010 to about 10% for 2011, 2012 and 2013. There are a number of possible explanations for this. The financial crisis of 2008 might have incentivised more research organisations to seek EU funding. Some later call topics were particularly broad and non-prescriptive and thus may have invited a wider range of approaches. An increase in certain types of research, particularly farming systems research and research more relevant to breeding practice, may have attracted a wider range of applicants.

In fisheries and aquaculture, the average success rate was 38%, the highest in FAFB. The lowest success rates were observed in the first two years 2007 and 2008 (26%) and increased later as the Ocean of Tomorrow calls were implemented.

The scores for the funded (winning) proposals is a good indicator of how successfully the principle of funding excellence is applied. Overall, the proportion of proposals passing the threshold ranged from 50 to 60%. The scores of winning proposals are almost always well above the threshold. The quality of winning proposals is generally high. This is supported by reviews of DoWs resulting from successful proposals. Almost without exception, DoWs comprise detailed, high-quality research project plans. In the agriculture thematic area we examined success rates and the scores for wining proposals in some detail and observed that highly competitive calls (i.e. low success rates) are not associated with particularly high quality winning proposals. The scores of the winning proposals declined as the number of proposals per topic increased in 2011 to 2013, when call topics became less prescriptive and attracted more proposals. This indicates that increasing competition by broadening topics is not a reliable way of increasing the quality of goal-orientated research proposals.

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[32] COMMISSION DECISION on three measures for simplifying the implementation of Decision No 1982/2006/EC of the European Parliament and of the Council and Council Decision No 970/2006/Euratom and amending Decisions C(2007) 1509 and C(2007) 1625. 24 January 2011.

We conclude that the programme as a whole is characterised by competitiveness. Because the programme is not designed just to fund "excellent" science, and especially because of the differences in competitiveness across the programme, it cannot be said that "excellence" *per se* has been achieved in project selection. The variation between areas in success rates might suggest that very active areas of EU science were less well supported than other areas. However the small numbers involved make it unwise to draw any firm conclusions. Judged by award rates in national research funding bodies the average proportion of proposals funded would indicate that there was a good balance between budget and competition. The relatively low success rate in food (13%) is one argument for increasing the budget for food research in forthcoming programmes, taking into account both the critical importance of diet and nutrition in improving the health of the European general public and the very strong economic significance of the European food industry.

Table 2. Research funding and proposal success rates for the seven annual work programmes

Work programmes	Total funding (€million)	Success rates %
2007	311	15
2008	98	11
2009	194	14
2010	217	15
2011	278	18
2012	313	19
2013	425	16

4.3 Effectiveness of dissemination of knowledge

4.3.1 Communication and dissemination activity

Overall, the research programme is characterised by extensive efforts to disseminate knowledge using a very wide range of communication tools. Nearly all finalised projects (97%) report dissemination activities. For the 107 completed projects, a total of 9,280 dissemination activities were reported in final reports (Table 3). The programme as a whole is characterised by high scientific outputs in the academic press (discussed later).

Table 3. Number of dissemination activities recorded by 107 completed projects.

Type of dissemination activity	**No.**
Peer-reviewed papers, conference proceedings, book chapters	6,872
Organisation of workshops	201
Organisation of conferences	183
Oral presentations to scientific events	172
Flyers	167
Theses	136
Interviews	104
Exhibitions	73
Videos	59
TV clips	38
Presentations to wider public	34
Media briefings	33
Films	4
Other dissemination activities	1,204
TOTAL	9,280

Descriptions of Work typically set out a wide range of communication and dissemination activities in work packages dedicated to such activity. Where we could assess the resourcing of this, we estimate that about 5-10% of resources are dedicated to dissemination.

Although it is obviously essential that good quality, peer reviewed academic papers are published from this publicly funded research so, there is also an increasing demand from civil society for access to results of such research, and from the general public for specific areas (particularly food research). Some food projects made considerable efforts to engage with civil society and the general public during the project life through different media (including TV, radio, print and, latterly, social media through blogs and online consultation). With some exceptions these communications were largely one-way: from the project to the public or civil society. There was little discussion in the formal documentation of how projects had managed the communication of complex scientific research to a lay, or partially informed, audience, or to policy makers, except for projects that had specifically recruited partners to undertake these tasks.

Impact plans and communication strategies are rare and there is little indication of strategies to maintain impact after the end of the project. Many dissemination activities are quite transient in nature (project websites, workshops) and now include the use of social media. Project websites were provided in an unstandardized way by consortia, and in some cases there were even two different websites for the same project. Many websites were not maintained long beyond the project term.

4.3.2 Technology transfer

It is particularly difficult to examine technology transfer in research which is still on-going, but we can comment on plans and approaches evident in DoWs etc.

The majority of patent applications that we know about were submitted to the EPO recognising the importance for Europe-wide protection. Although the FP7 programme is open to private industry and a significant number of topics set out research for SMEs, patenting activity is largely led by the academic research partners. This was observed in all thematic areas, but with some evidence found of SME and other private sector partners securing patents in biotechnology (BASYNTHEC and MEM-S). In agriculture, we identified 14 from 36 completed projects that had reported items of protectable foreground IP. In agriculture, there were four times more publications than foreground outputs and nearly half of the reported foreground outputs were intangible in nature. The reliance on publication of outputs and the diffusion of ideas, processes, models etc. reflects the public good nature of the research results. Protectable IP tended to come from research relevant to plant and animal breeding, and animal health.

Explicit impact pathway planning is not general, although it was more evident in development and demonstration projects, and some biotechnology projects in particular set out clear roles for SME partners in taking up results. Good examples of planned technology transfer pathways include COFREE where SMEs partners actively provided innovation pipelines. The PARAVAC project integrates an international product development consultancy that provides SMEs and multi-national animal health companies with the external product development support they need for later commercialisation. Mutually-owned private sector partners are prominent in agricultural research and their engagement in the research reflects well thought-through approaches to technology transfer. Very good examples are the presence of Biogemma in plant breeding research, and mutually owned animal breeding firms in animal improvement research.

4.3.3 Quality of reporting

From our wider experience of the programme, we have no reason to believe that there is insufficient effort put into reporting. However the reporting is focused on contract deliverables and milestones rather than on conveying insights and results to external readers. Some consortia use their websites to provide public access to their reports to the EC, but many of these reports etc. are not written for a public audience. They are largely written for contract management purposes. ROBUSTMILK and Legume Futures are examples of several projects that combined project reporting and disemmination (other examples are: ICONZ, CERCOST, LOWINPUTBREEDS, AGRIXCHANGE, FACTOR MARKETS).

The contract reports available to the reviewers were of variable quality. Dissemination would benefit if there was a clearer structure to reports that, without diminishing the adherence to contract deliverables, focuses on explaining the science and results. More could be done to ensure reports provide considered reflections on progress and final achievements in a way that is useful to those outside the project.

Overall, we consider that project consortia and the Commission pay adequate attention to reporting and communication but that improvements in the efficiency of dissemination are possible through a programme-wide move away from be-spoke approaches, better targeting using impact and communication strategies (and pathways), and modifications to contract reporting integrated with improvements in dissemination.

5 Achievements and impacts

In line with our Terms of Reference, we present our evaluation of achievements and impacts in relation to:

- impact on science;
- technological impacts and impacts on innovation;
- economic, environmental and social impacts;
- structural impacts on the European Research Area;
- impact on EU policies; and
- European added value

We were also asked to consider how well projects meet their objectives. Completed projects had a good record in achieving the contract objectives. The assessment reports generally report commitment to adhering to project plans and objectives. In the rare cases, delays in achieving objectives are rigorously noted by the EC and this contributes to a culture of commitment to contract deliverables. Six broad target groups of end-users of research can be identified. These are:

- farmers, foresters, fishermen and other primary producers;
- technology providers, the service and input supply sectors, e.g. breeders, forest management planning services, fisheries management bodies;
- the food industry;
- the non-food bio-based industries;
- policy-makers;
- other scientists.

There also indirect and intermediate beneficiaries. Consumers in general are an indirect beneficiary of research, particularly research on organic farming, animal health and welfare issues, and research on diets and health effects. Educators and students are indirect beneficiaries of all the new knowledge generated.

For the consumer related research in food, the primary users are in the scientific community, including scientists in the policy community. Secondary users are the consumers themselves, the food industry and others involved in communicating health aspects of specific foods to consumers. In projects more directly oriented on consumers (such as projects related to nutritional labelling), the food industry and NGOs are the first level users of project results.

In the nutrition area, most of the primary users are in the scientific community and also among policy makers who draw on project findings for the scientific basis of dietary advice and regulations. Health professionals are secondary users. In projects where the nutritional performance of ingredients and components are assessed, the food industry and SMEs are seen as second level users. The primary users of scientific results in the food processing area and in research on environmental impacts are in the food industry including food SMEs. In some projects, the scientific community is the secondary user of the results. Regulators and policy makers are the primary users of research on novel foods and environmental impacts. The same applies for much of the research in food quality and safety.

The primary beneficiaries of research supporting sustainable primary production are often actors that support technical change in farming, forestry and fisheries: plant breeders, businesses in animal genetics, machinery and gear suppliers, diagnostic services etc. Many projects have developed models, procedures or e-tools with the aim of standardising data and knowledge and transfer it to the farming sector. Ultimately consumers are the end beneficiary of much of the research through the reduction in food prices that comes with technical change, safer food and reduced impact on the environment.

In the case of animal sciences, animal welfare and the zoonosis related research may have a particularly direct impact on society. Neglected zoonotic diseases (NZD) have a devastating effect in Africa and the eradication or at least decrease of these epidemics is an important social objective. In the case of zoonosis related research there are some other good examples of wider societal benefits, including in Africa, for example raising awareness and training on biosecurity or vaccination campaigns.

Much of the agricultural and fisheries research is characterised by research outputs which are public goods in themselves, including policy research leading to recommendations to increase the effectiveness and the efficiency of organic certification (CERCOST), or encompassing standardisation of data exchange and the ICT priorities in agro-food sector compiled in a Strategic Research Agenda (AGRIXCHANGE). Other public good outputs are exemplified by LOWINPUTBREEDS focused on gathering all R&D results in a handbook for organic and low input animal breeding and management. Even improved cereal germplasm is in effect a public good due to the unrestricted access to it under current plant breeders' rights for use in breeding. The fisheries research is almost all public good research and plays a key role in efforts to achieve recovery of European marine fisheries.

In biotechnology, interaction within projects between primary users in science and secondary users in industry was observed, the secondary users being SME partners in the projects. This was linked to the combination of strategic generic research and specific process or product development within projects.

5.1 Increase in knowledge

We were asked to assess if the project increased the body of knowledge. All the projects intend to increase the body of knowledge but in very diverse ways. We can only give a broad idea of the type of increase in knowledge.

Large number of publications and other types of dissemination activities in websites, workshop and conferences have contributed to a general increase in the body of knowledge among the scientific community, the legislators and other policy makers, as well as in relevant industries and to some extent the general public. For the project participants, the increase in knowledge has been more direct, often involving knowledge transfer from one partner to another including from scientific partners to SME partners.

Typical agricultural research includes the definition of beneficial phenotypes; the application of 'omics' to realise these new phenotypes; and measures for disease surveillance and disease resistance, interactions in animal production between breeding for disease resistance, nutrition, animal health and alternatives to the use of antibiotics. These outputs provide opportunities to follow research with targeted developmental activity. The impact on farming and forestry in particular is usually incremental. However, considering the incremental nature of progress that can be expected, the research is characterised by a focus on tangible research outputs such as tools and models to support decision-making and practice.
Some aquaculture projects produced or are expected to generate knowledge that belongs to more basic areas of cell and molecular biology, microbiology, genetics and genomics contributing to the advancement of cutting-edge research areas beyond their field of application.

For the biotechnology activity, the following examples are relevant:

1. EU-PEARLS (funded in 2007) sought new production crops and systems for European rubber production providing molecular, biochemical, and germplasm information while DRIVE4EU (funded in 2013) is designed to produce first generation products such as tyres from this.

2. ENERGYPOPLAR furthered our understanding of root fungal systems for growth and yield. Also, full life cycle inventory data on poplar for biofuel use in several locations is now in the public domain.
3. METAPRO improved our fundamental understanding of plant metabolic pathways and their regulation to improve sustainable bioproduction of valuable carotenoid compounds *in planta*, and successfully brought this to the feasibility (demonstration) stage.
4. NOVOSIDES sought to improve our understanding of biocatalysis and produce novel enzymes by screening germplasm and directed mutagenesis.
5. The MAMBA and the MICRO B3 project will lay ground for future rationale product discovery from marine environments.
6. The SUNBIOPATH project provided valuable information for the design of algae-based biorefineries.
7. ANIMPOL from the environmental area successfully developed industrial processes for conversion of waste from animal processing.
8. SYSINBIO was very successful in coordinating research efforts and advanced education in the field of model guided metabolic engineering in Europe.

5.2 Impact on science

The FAFB programme is strongly characterised by quality assurance using external peer review. This provides the foundation of a high impact on science. In addition, there is impact on science through education which is discussed here also.

Of the 107 of the completed projects, 86 (80%) report at least one academic publication. The total number of the publications at the reporting date of 3rd of March 2014 was 1,414. This is equivalent to 54 publications per €10 million invested. The EC classifies nearly half of these publications as 'high impact' (based on the journal used).

In agriculture, the overall publication output was very similar to the FAFB programme as a whole. Only a few biotechnology projects have finished but to date two in particular have a combined output of 29 papers. Almost all of the research projects result in conventional academic publications. This high performance is observed in all areas of the programme, including organic farming research which at national level is sometimes characterised by low publication rates (e.g. BLE report on the impact of the German organic farming research programme[33]). This indicates that the discipline of peer-reviewed publication is well embedded across the research. We saw no evidence that publication potential or performance is compromised by inter- or multi-disciplinarity, or closeness to practice. This strong performance will have long term impact through spill-over of the discipline of this type of publication into national programmes. We expect that the discipline of academic publication is being reinforced throughout the EU within projects which results in a strengthening and levelling of the ERA over time.

5.2.1 Education

Education is relatively rarely mentioned in the calls or DoWs and so it is difficult to formally assess impact on education. Final reports indicate that early stage researchers make significant contributions to the projects. In agriculture, the reports of the 36 completed projects report 48 theses. From our experience of the research consortia, we expect that this understates the impact of the programme through education. Higher education

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[33] Ekert, S; Döring, T., Häring, A.M.; Lampkin, N., Murphy-Bokern, D., Otto, K., Padel, S. and Vieweger, A. (2012). Evaluation of the German Federal Research Programme on Organic Agriculture. BLE (http://orgprints.org/22369/).

establishments and a significant proportion of other participants are closely related to higher education. They accounted for 35-40% of participants in the early phase and 25-30% in the later phase of the programme. The absolute number of HE participants remained stable, but the proportion declined due to the increase in the inclusion of SMEs.

Some projects across the FAFB programme specifically offered academic courses, and training courses for researcher participants and/or stakeholder participants. Below we have some examples of these educational activities:

- PARAVAC reports short term staff exchanges, training courses. They have calls for these training events on the website and the possibility is offered to all consortium members to organize these financed trainings locally and the consortium provides standardized rules and guidelines for organisation and administration (http://paravac.eu/index.php?page=training).
- GLOWORM reports training activities for consortium members even though this was not an explicit purpose of the project. Several staff exchanges were also established between participating laboratories. Two GLOWORM GIS courses was held and attended by 17 young scientists from the different GLOWORM participants; a workshop on Spatial Analysis was held and was attended by 12 young scientists from the different GLOWORM participants.
- The LOWINPUTBREEDS project reports that 120 staff were trained.
- EADGENE_S funded 5 post-graduates and trained 9 other staff. They state in the periodic report that partners are collaborating through the training Erasmus EGS-ABG an European Graduate School in Animal Breeding and Genetics through jointly PhD projects, together with an industrial partner in most cases, illustrating a successful third-party private financing mechanisms.
- WATBIO has a work package dedicated to education and training in advanced breeding techniques for perennial biomass crops.
- GplusE includes a significant education effort. This will provide Europe with trained professionals in the area of precision animal breeding.

Table 4. The twenty journals most frequently used in the 107 completed projects

FAFB rank		SJR[34]	No. of Publications	% of all publications
1	Environmental Microbiology	2.7	24	1.7
2	PLoS One	1.8	23	1.6
3	Applied and Environmental Microbiology	1.6	20	1.4
4	Journal of Dairy Science	1.2	20	1.4
5	Plant Physiology	3.1	18	1.3
6	Plant Journal	3.5	16	1.1
7	New Phytologist	2.5	15	1.1
8	Plant Cell	4.8	15	1.1
9	Proc. of the Nat. Acad. of Sciences	5.4	14	1.0
10	Applied Microbiology and Biotechnology	1.2	13	0.9
11	Mutagenesis	0.9	13	0.9
12	Food Chemistry	1.7	12	0.9
13	Plant Biotechnology Journal	1.8	12	0.9
14	Vector-Borne and Zoonotic Diseases	0.9	12	0.9
15	Acta Horticulturae	0.2	11	0.8
16	Biofuels, Bioproducts and Biorefining	1.8	11	0.8
17	Journal of Virological Methods	0.8	11	0.8
18	Animal	0.9	10	0.7
19	Bioresource Technology	2.0	10	0.7
20	Journal of Biological Chemistry	2.8	10	0.7
	Total		290	20.5

Table 5. The frequency of publication by 107 completed projects in the highest ranking journals

No.	Journal title	SJR	Number of academic papers
1	Nature Genetics	19.9	2
2	Cell	19.8	1
3	Annual Review of Plant Biology	14.7	1
4	Nature	14.5	6
5	Science	11.2	1
6	Genome Research	10.8	1
7	Developmental Cell	9.2	1
8	Nature Biotechnology	9.2	1
9	Trends in Ecology and Evolution	8.7	1
10	Annual Review of Microbiology	8.1	1
11	Ecology Letters	7.9	4
12	Cell Metabolism	7.7	1
13	Nature Reviews Microbiology	7.2	2
14	Trends in Biochemical Sciences	7.0	1
15	EMBO Journal	6.6	2
16	Trends in Genetics	6.3	2
17	Molecular Systems Biology	5.9	3
18	Nature Protocols	5.8	2
19	Advanced Materials	5.7	1
20	Proceedings of the National Academy of Sciences	5.4	14
	Total		48

[34] SJR. SJR is the SCImagio Journal Rank Indicator. It is a measure of journal's impact, influence or prestige. It expresses the average number of weighted citations received in the selected year by the documents published in the journal in the three previous years.

Table 6. The academic papers from the 107 categorised according to journal subject areas.

No.	Journal Subject Area	Number of academic papers	% of all FAFB publications
1	Agricultural and Biological Sciences	577	40.8
2	Biochemistry, Genetics and Molecular Biology	390	27.6
3	Immunology and Microbiology	86	6.1
4	Environmental Science	82	5.8
5	Chemistry	55	3.9
6	Medicine	55	3.9
7	Chemical Engineering	45	3.2
8	Multidisciplinary	25	1.8
9	Economics, Econometrics and Finance	10	0.7
10	Energy	10	0.7
11	Neuroscience	10	0.7
12	Pharmacology, Toxicology and Pharmaceutics	10	0.7
13	Materials Science	9	0.6
14	Social Sciences	9	0.6
15	Engineering	8	0.6
16	Business, Management and Accounting	7	0.5
17	Earth and Planetary Sciences	6	0.4
18	Computer Science	5	0.4
19	Veterinary	5	0.4
20	Arts and Humanities	2	0.1
	Total	1,406	99.4

5.3 Technology impacts and impacts on innovation

In considering technological impacts, it is also important to note that there are contrasts within the programme. Food, agriculture and fisheries are focused on technical change in specific sectors whereas biotechnology is a technology focussed thematic activity. Biotechnology was seen as a key enabling technology relevant to transition to an economy less dependent on fossil fuels with lower carbon emissions.

Strategic food research for consumers typically did not focus on exploitable results but in some there are potential technological innovations, which could be further developed. One example was the project CONFFIDENCE where 2 patents have been granted for analytical tools for detecting contaminates in foods, and where commercial exploitation is already taking place. Two newly started projects will bring forward the European knowhow in pick and place food packaging automation as well as 3D printing of designed foods for elderly people with special dietary requirements (PERFORMANCE).

In general terms, production agricultural research raises the innovation capacity of the farming sector by diffusion of knowledge. Parts of the agricultural research are characterised by focus on some key enabling technologies, particularly animal and plant breeding on the farming side and veterinary medicines on the animal health side. The work on low input farming supports innovation that reduces reliance on some technologies and the replacement of inputs with more knowledge-intensive approaches. This type of innovation is heavily dependent on diffusion of knowhow.

A special feature of fisheries research is it aims mainly at improvement and innovation of fisheries management – by addressing and overcoming identified existing shortcomings – in order to achieve a higher degree of ecological and socio-economic sustainability of fisheries. Similarly, a significant proportion of agricultural research related to developing knowhow, understanding risks and informing public policy. Resource protection and ecosystem assessment was also a theme, particularly for forestry.

5.3.1 Research and innovation capacity of industry

There are two aspects to the question if and how the programme has increased the research and innovation capacity of industry participants. The first is the impact on the research capacity of participants, and the second is about the research and innovation capacity of industry as users of research.

Obviously when private sector participants provide research services in projects, this increases their research capacity simply through the corresponding volume of research conducted. The impact on the participants' capacity to innovate is less clear due to weaknesses in the role of SME participants (discussed below). However, some examples show that the participation of private sector can have large impacts in this way. A good example is the TriticeaeGenome project that boosts industry partners' (breeders) research capacity collectively and also boosts their capacity to lead innovation in their sectors.

5.3.2 SME engagement

The data we refer to here relates to the participants who flag themselves as SMEs in proposals. It was the only consistent data set available to us but there is some uncertainty as some may not have been confirmed as SMEs in subsequent checks.

In the later years of FP7, many of the call topics required the participation of SMEs to meet a target of 15% of funding going to SMEs. This resulted in a clear increase in the SME participation of the projects (Figure 3), reflected in increased funding allocations (Figure 7 and Figure 8). Overall, the allocation to SMEs increased from 8% in 2007 to 28% in 2013. As an example of the response, the share of SME participation in agricultural research increased from approximately 10% up to 2011 to 20% of participants from 2011 onwards. The corresponding increase in the proportion of funding was approximately 6% to 22%. Biotechnology had the highest rate of SME participation at 24% and was responsible for nearly half of all SME funding from the 2012 and 2013 work programmes.

A total of 1,310 enterprises that flagged themselves as SMEs participated in FAFB projects and 1,188 (91%) of those are private-for-profit firms. The allocation of funding to SMEs at project level was commonly close to the minimum required by the EC indicating that funding requirement rather that the consortia requirements for impact were the main driver. While participation by SMEs in biotechnology projects sometimes exceeded that of public sector researchers, some of this was from research-based SMEs that are close to academic institutions or otherwise involved in research rather than in developing commercial products and processes.

SMEs constituted 24% of the participants in the food projects. A large proportion of the SMEs in the food processing, quality and safety research were equipment producers involved in the development of new innovative technical solutions for the food industries. These SMEs were involved in practical implementations of new technologies or methods. In most food projects, the EU contribution to SMEs was quite small, between 5-10%, but there were a few projects where the EU contribution to the SMEs was more than 50%; mainly related to equipment developing SMEs.

In the fisheries and aquaculture area, it is estimated that approximately €25 million went to SMEs, constituting a 16% of the EU contribution in the thematic area. Aquaculture research focused on fish farming was characterised by SME participation close to the minimum. Higher rates of participation were evident in research relevant to high-tech developers in the Ocean of Tomorrow projects. This might be due to the greater willingness of these firms to invest in research or it may be due to the greater research capacity and interest of these types of companies.

Generally, the scope for participation of classical for profit SMEs in 'public-good' fisheries research was limited. Therefore, in the fisheries research, the requirement to include SME partners resulted in participation of SMEs providing various services (e.g. website management, dissemination, facilitation of group processes) and only in very few cases was there involvement of the industry.

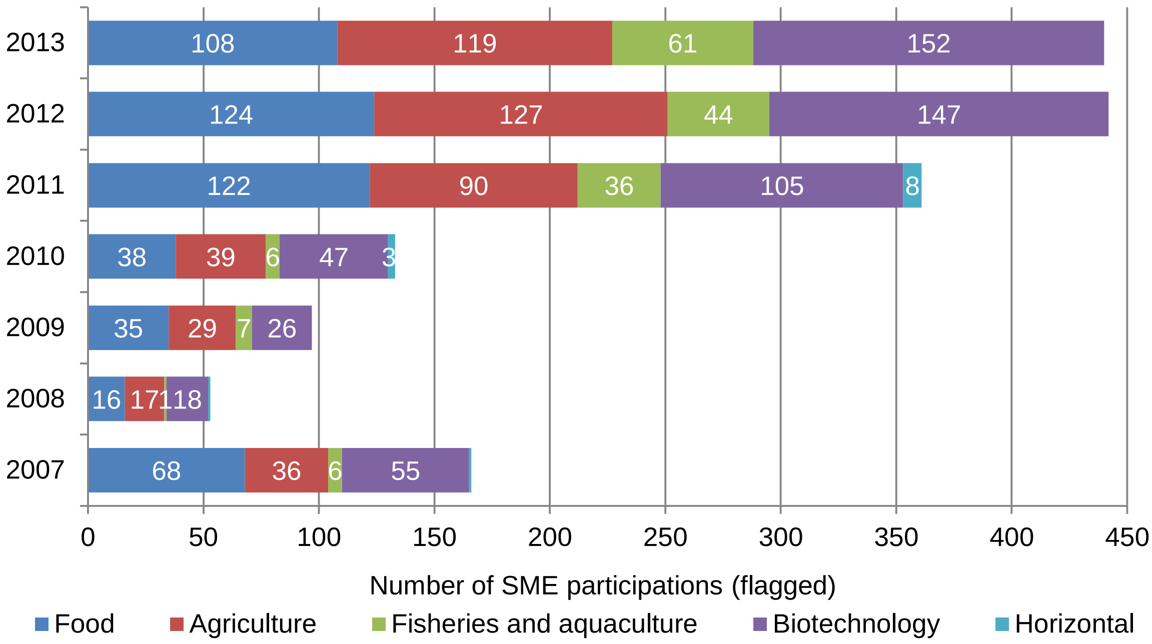

Figure 3. The number of SME participations in projects in the thematic areas[35]

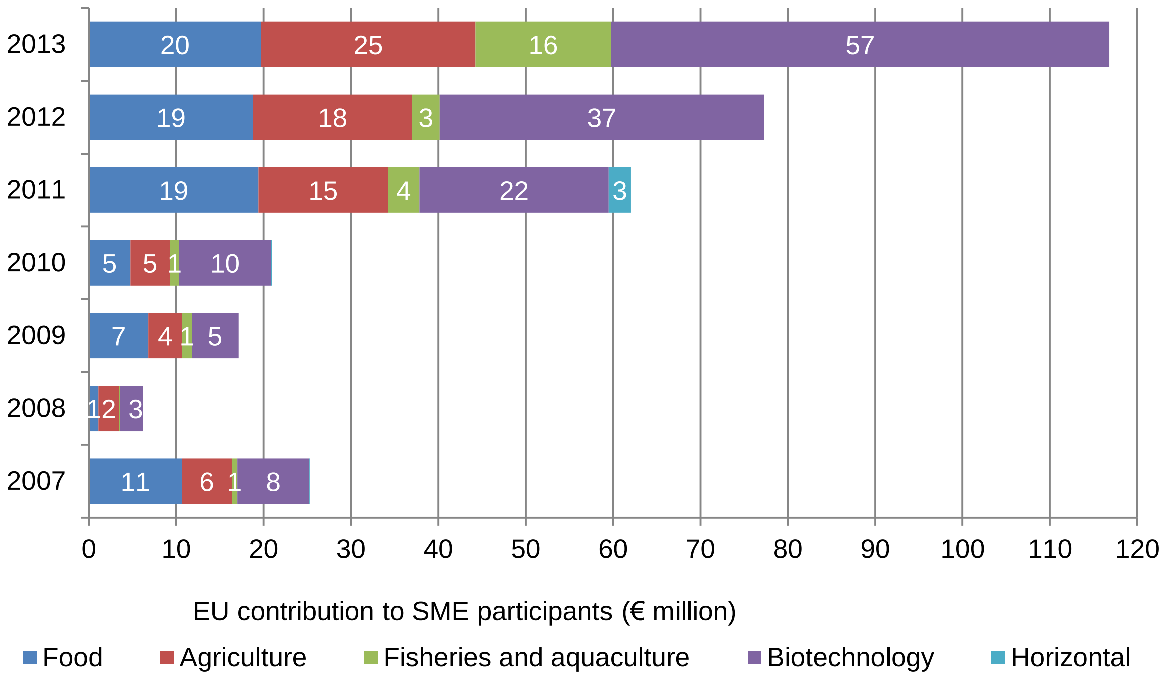

Figure 4. The allocation of EU funding to SME participants in projects in the thematic areas.

[35] These data relate to participants who flagged themselves as SMEs.

Large Enterprises (LEs) had a minor role, whereas the participation of producers' associations and other type of national and international organisations was common and beneficial in agriculture and fisheries research.

An evaluation on the SME participation of FP7 programmes concluded that generally SME participation was often not focused on the generation of commercial impact from results.[36] Our observations support this. Of the 515 projects, 403 (77%) had SME partners and 38 projects were coordinated by SMEs (7%). Of the 38 projects coordinated by SMEs, 13 were in food, 13 were in agriculture, 2 were in fisheries and aquaculture, 8 were in biotechnology, and 2 led in horizontal activities. In some parts of the programme (e.g. in agriculture and in fisheries) we found relatively few examples of SMEs describing themselves prominently as beneficiaries of research outputs (in the relevant part of the DoWs). They typically described themselves primarily as providers of research or other services. But there are some examples of SMEs playing a more strategic role, particularly in the recent development and demonstration projects (e.g. PROLARIX). A good example is the GLOWORM project, which links up fundamental and applied research to developments of SMEs partners. It delivered the Vet-geo Tools spatial software package enabling a more rapid and efficient spatial management of veterinary disease outbreaks (within the project the company will develop prototype additional functionalities aiming at an improved management of endemic diseases). The new development and demonstration projects introduced in 2012 include SME partners as strategic beneficiaries of the development work. Also in biotechnology, SME partners describe plans to develop research results. However, overall and even where SME partners develop results, they generally do so as recipients of results of research driven by academic partners.

5.3.3 Inclusion of the innovation dimension

At the beginning of the FP7 programme, the EC said that "innovation-related aspects need to be clearly addressed and well-defined dissemination and exploitation plans presented, showing the optimal use of project results".[37] This is a sound approach to innovation. This was reinforced in 2012-2013 which included calls dedicated to "innovation measures in support of activities closer to market with more activities aimed at generating knowledge to deliver new and more innovative products, processes and services". This approach to dedicated innovation projects is in the early phase of implementation. A case study conducted in the agriculture thematic area focused on some of these and concluded that they were effectively supporting innovation. These projects included a decisive role played by SMEs in the commercialisation of outputs which shows that private sector partners will adopt a more strategic position if the circumstances favour this.

Overall, compared with other equivalent public research programmes, the innovation dimension is a defining feature of the FAFB programme. For a programme historically rooted in public research funding, it goes to considerable length to embed delivery of outcomes through supporting innovation into the research process and community.

Basic and strategic research does not focus on exploitable results but in much of the research there are potential innovations, which could be further developed. We emphasise that patenting is only one indicator of the potential impact of research through innovation.

Overall for FAFB, 20% of the 107 completed projects report to have taken out at least one patent, the total number of protected intellectual property items is 64 with 52 being reported as patent applications. 47 of the 52 patent applications came from the biotechnology area of the programme. This is 6.2 patent applications per €10 million invested although this is a

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[36] Performance of SMEs within FP7 An Interim evaluation of FP7 components, Panteia, http://ec.europa.eu/research/sme-techweb/pdf/volume_i_smes_in_fp7-may2014.pdf

[37] EC 2006. Work Programme 2007-2008. Cooperation Theme 2. (page 8)

crude measure when there are other forms of exploitation which are effective such as copyright, design rights, trade secrets etc. in addition to exploitation out of the public domain.

Many of the projects in the food activity included demonstration or targeted dissemination activity. Often a prototype of a new method or technology was developed and installed at the facilities of a project partner. The objective was then to demonstrate the novelty to end users in order to widen and find new markets. However, in other food projects there remains still much work to be done to transfer the developed scientific results to commercial products. Proper estimations of market potential of the developed technology, method or materials were not done within many of the projects.

Many biotechnology projects were also directed to pilot plant development or testing and therefore may not produce exploitable products but rather a mechanism of developing a process through know-how. Particularly in agriculture, fisheries and aquaculture, exploitation and commercialisation are not the same. Research can support commercially relevant innovation without any patent being filed. This is relevant in all conventional breeding research (where plant breeders' rights predominate), research on animal nutrition, cropping systems, and all research about production practices generally.

IP management is usually addressed in the DoWs or interim reports in a general way. In project DoWs, there are few examples of plans for managing specific outputs within impact pathways. DoWs commonly refer to an IP manager or an exploitation committee and make standard references to background IP being owned by originating partners while foreground is by default the property of the discovering partners. The standard EU collaboration agreement provides a clear framework for managing IP and there are good examples of this being used well (TriticeaeGenome). This supports a wide range of approaches including revenue sharing and licensing (PROLARIX); license of the technology where partners do not have the production capacity to meet market demand (FLHEA), or joint ownership with access rights granted on a royal-free basis (ALL-SMART-PIGS). Four patents are expected from the development and demonstration projects within the topics for innovation-related projects. In food, research on processing commonly used dedicated IP managers with responsibilities to safeguard commercial applications. Some of these projects have also resulted in patents and other types of commercially exploitable outcomes.

The analysis of completed agricultural research (36 projects) identified 68 items of tangible foreground IP. These are gene variants, markers, selection tools, tests, methods, vaccines, software, isolates, and instrument innovations. The large investment in 'omics' research to support plant and animal breeding involves the demonstration of this technology in 'upstream' markets, for example markets that provide scientific support or services to animal breeding organisations. GplusE provides a good example of research that spans basic research through to the point where the utility of that knowledge is demonstrated to this type of potential user.

It should be noted that the fisheries projects mainly aimed at improving fisheries management to achieve a higher degree of ecological and socio-economic sustainability of fisheries. Only a minority of them addressed technological innovations and it is not expected that they will result in technological innovation *sensu stricto* in most of the cases.

Aquaculture research has been very prolific in generating foreground IP, yet only a few plans for patent applications or other ways of safeguarding the intellectual property rights (IPR) to future commercial applications could be traced in the project documents. Thus, the projects differ deeply in terms of types of intellectual property rights and commercial exploitation of results. Some distinctive cases are presented here.

One of the academic partners in LIFECYCLE launched a spin-off company in February 2013, specialised in aquaculture genetics services. This commercial development represents the commercialisation of over 30 years of basic research on the physiology and genetics of fish muscle growth and flesh quality and was made possible by continuous support from the UK Research Councils and the European Commission, the later through SEAFOODplus (FP6) and LIFECYCLE (FP7). The core business of Xelect is the developing of genetic markers for brood stock selection. Xelect has licensed genetic markers for superior meat yield in Atlantic salmon to SalmoBreed A/s and Landcatch Natural selection and several other license opportunities for this and other traits are currently under negotiation.

SELFDOTT achieving the control of Bluefin tuna reproduction, building on previous research. Additionally, significant progress was made in larval rearing and in the formulation of compound diets for juveniles. The success of SELFDOTT led to TRANSDOTT, a project that will develop all knowledge produced through EU funded research to support industrial application. The approach adopted with REPRODOTT, SELFDOTT and TRANSDOTT provides evidence that methodical step-by-step pursuit of objectives using a programming approach (in this case informal) can lead to innovation and industrial leadership.

The Ocean of Tomorrow projects (SMS, SEA-ON-A-CHIP, MARIABOX, ENVIGUARD, BRAAVOO) were implemented to deliver explicit commercial applications (novel automated system for in-situ monitoring; miniaturized immune-sensor) and boost marine technologies.

The biotechnology thematic area is expected to using patenting as a route to impact more than the other FAFB activities. The few completed biotechnology projects do not make it possible to provide meaningful quantitative information. The number of any type of output will depend entirely on the type of project. Some biotechnology projects have produced several patent applications e.g., PLAPROVA produced 7, FORBIOPLAST produced 4 and IRENE produced some 4 patent applications and papers 17 whereas EU-PEARLS produced one patent application. In the marine biotechnology field, the MAMBA project is outstanding with respect to IPR generation and marketing. Patents were filed during the project, and successfully marketed (and licensed) to SMEs, large industrial companies and innovation networks (the German CLIB cluster).

Proof of concept and prototyping was the most typical way of exploiting results. A highlight was PLAPROVA: Evaluation of potential plant-based vaccines against a number of diseases of great and increasing importance to both the EU and Russia. This project has been flagged as success story by the Commission and the coordinator has been awarded the prize as Innovator of the Year and Most Promising Innovator winner by BBSRC (UK).

5.4 Economic, environmental and social impacts

The potential economic, environmental and social impacts vary significantly between thematic areas. For some, “big issues” relating, for example, to the sustainable development of farming, the protection of marine ecosystems, or to dietary guidelines for healthier lifestyles are addressed directly. For others, societal impact is achieved indirectly through specific goods and services leading to economic development.

A large proportion of consumer, nutrition food quality and food safety research was policy oriented or precompetitive and is not expected to lead directly to industrial innovation. However new research tools were important outcomes, such as software, analytical tools etc. In research on food processing, packaging and food chain environment impact, there were numerous examples of project outputs leading to innovations, where the most common were new sensors for quality and process control, IT tools for modelling and analysis of data and new processing and packaging technologies. New food ingredients and bacterial strains with favourable properties were also innovative outcomes.

Many of the more academic food projects created IT based, tools for participants and stakeholders, which could have commercial value, although it was often not clear who would promote and commercialise the tools. If such tools are only used by a very small number of partners or stakeholders, the value of the tool and the intended impact on innovations is diminished. In the cases where projects sought to develop new food products, the fate of the new products seemed generally to have been left to the participating food industry. Many food research projects lacked proper commercial assessment, so the impact on product innovations was difficult to assess. Furthermore, the legislative difficulties (e.g. novel food legislation) of introducing new methods or ingredients in EU were seldom considered.

Public health is a major beneficiary of outcomes from the research projects in consumer and nutrition areas. Public health issues include both dietary issues and concerns from contaminants in foods. A couple of projects were oriented to communication strategies for influencing consumers toward more healthy lifestyles. The targets for these projects outcomes were often health professionals and through them, the general public. Also in the other research areas the potential improvement of public health has been an important outcome of the projects.

For many of the more food industry oriented projects, the major environmental benefits relate to reductions of energy and water use, as well as reduction of material and food waste. These measures will increase the competitiveness of the EU food industry, together with other projects more oriented to improving the efficiency of food production and food handling in the total food chain. Many of the newly started projects will help to improve the processing efficiency and thus drive the economic growth of food and related industries.

A few food projects assessed the environmental impacts of supply chains. This included developing a new assessment tool that jointly considers environmental, social, and economic impacts. Widespread use of this tool will have a potential to contribute to improving the sustainable development of the EU food chain.

Compared with FP6, agricultural research addressed a much wider range of societal goals because it was not confined by the 'fork-to-farm' boundary set in FP6. Beyond the well-established impacts of agricultural research through technical change and diffusion of knowledge, animal welfare and the zoonosis research directly impacts on society through disease control, which includes the control of zoonotic diseases that have devastating effects on people in Africa. Better knowledge of epidemics and disease control can decrease the geographical area of restrictions for trade and eradication of farm animal and the scale of culling in case of wild species (e.g. the objective of WILDTECH). This connection between animal health research outcomes and economic impact illustrates well the indirect link between animal health as a public good and economic impacts. Analogous effects occur in the case of plant health research.

Research supporting the improvement of fisheries management has indirect economic and social impacts. These impacts occur if, and only if, the results are used in decision making. Only indirect impact on labour markets, poverty and inclusion, etc. is expected, e.g. through establishing a sustainable fishing industry in Europe. Given the condition of our fisheries, research on fisheries management, if used in decision-making, leads to reductions in fishing activity. Hence, an increase in the employment level (directly linked to the size of the fishery fleets) cannot be expected in the near future as a result of fisheries research.

The common societal impact of all the aquaculture projects is the direct or indirect contribution to food safety and food security that in turn have economic impacts on a range of stakeholders from the producer to the consumer level throughout the entire aquaculture value chain. Social innovation is very often represented by processes that support public awareness through sufficient labelling, or the consideration of the full range of stakeholders involved in production processes. In addition, a significant part of the aquaculture research was designed to have a strong environmental impact by developing methods in favour of biodiversity and safeguarding the quality of aquatic environment.

The biotechnologies activity impacts on society largely innovations that are likely to improve the quality of life. To take one example the PLAPROVA took an innovative route to produce and test vaccines against animal diseases. As such it provides a good and successful example of how FP7 enabled the bringing together of a wide range of expertise in a multi-disciplinary way to provide a product with wide economic, social and environmental impacts.

5.5 Structural impacts on the European Research Area

The 2012 European Research Area Communication[38] defines the ERA as a unified research area open to the world in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States strengthen their scientific and technological bases, their competitiveness and their capacity to collectively address grand challenges. The Communication defined five priorities:

- more effective national research systems– including increased competition within national borders and sustained or greater investment in research;
- optimal transnational co-operation and competition- defining and implementing common research agendas on grand-challenges, raising quality through Europe-wide open competition, and constructing and running effectively key research infrastructures on a pan-European basis;
- an open labour market for researchers- to ensure the removal of barriers to researcher mobility, training and attractive careers;
- gender equality and gender mainstreaming in research– to end the waste of talent which we cannot afford and to diversify views and approaches in research and foster excellence; and
- optimal circulation, access to, and transfer of, scientific knowledge including via digital ERA- to guarantee access to, and uptake of, knowledge by all.

We use these priorities for the ERA as the framework for our assessment.

5.5.1 Effective on national research systems

The FAFB programme does not impact directly on national research systems, except through the ERA-NET mechanism (section 5.5.3). However, the indirect effects through raising research standards and facilitating mobility of researchers apply strongly. The interaction between scientists from different countries within consortia spreads ideas about good practice. The free movement of staff between collaborating partners, particularly early stage researchers, has profound long-term bottom-up effects in raising standards across the EU. This is particularly important in FAFB research where regional and national research systems have played a strong role.

5.5.2 Transnational cooperation and competition, pan-European infrastructure

As part of the FP7 cooperation programme, the FAFB research obviously contributes to transnational co-operation. Here we consider some aspects of the quality of that cooperation.

A highly tangible example of an ERA impact is the project HIGHTECH EUROPE where a number of food research laboratories provided access to each other's unique food processing equipment, thereby facilitating the dissemination of novel technologies and providing the opportunity for more research and innovation to be done with these pieces of equipment. The development of worldwide unique new technologies will also add value to ERA.

We assessed the depth and quality of the cooperation in case studies of the agriculture thematic area, both for the performance of the research and the delivery of outputs. Overall,

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[38] COM (2012) 392

almost all projects were classified as ‘very good’ in terms of the depth and quality of collaboration. The score for the cooperation in outputs and exploitation was generally lower than for the research process, but this is expected as the dissemination and exploitation generally require less extensive collaboration than the primary research phase. Good examples of long standing cooperation reported include:

- Animal health projects which build on the previous project results and consortia (e.g. STAR-IDAZ-EMIDA-ANIHWA; DISCONTOOLS-ICONZ). Thus we could find a growing amount of shared knowledge and a growing number of researchers working together regularly, providing real added value for the EU.
- Linked to the concentration of biological research (e.g. Strategic support to crop improvement, IPM, PRA) in the EU15, we see long-standing collaborations between particular major public sector research establishments and Universities in The Netherlands, France, The UK, France and Germany in various constellations across the programme.

There are clear indications of important ‘critical mass’ formed as a result of collaboration, particularly in areas of importance to policy (e.g. animal and plant health, agricultural and forest policy, fisheries). There is also critical mass forming in FP7 in animal and plant breeding research. The ordinary ‘every-day’ effects of collaboration are evident in the large number of dissemination outputs, and the exchanges between partners. The project management procedures used and the care given to collaboration agreements etc. all indicate that there is attention given to the collaboration *per se*. The attention given building and maintaining collaboration has long term benefits.

Types of organisations and patterns in cooperation between participants: The detailed examination of projects’ coordinators indicates strongly that the programme is dominated partners in the EU15. While most projects included partners from the new member states or third countries, these play a relatively minor role. This is reflected in data on the allocation of funding to coordinating institutions (Figure 5).

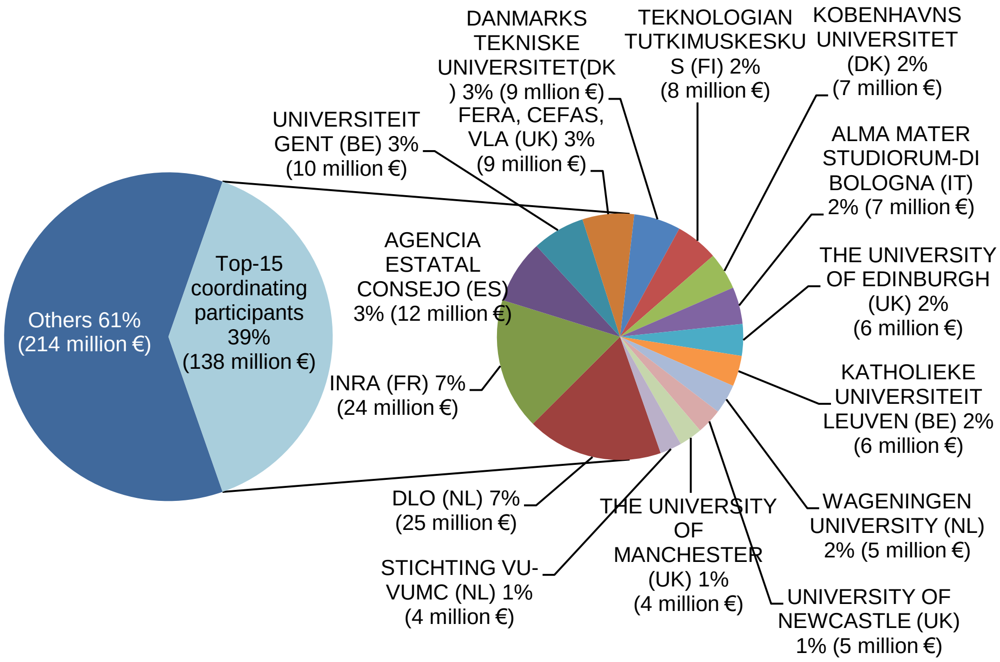

Figure 5. The allocation of funding to coordinating participants with the top 15 beneficiaries identified.

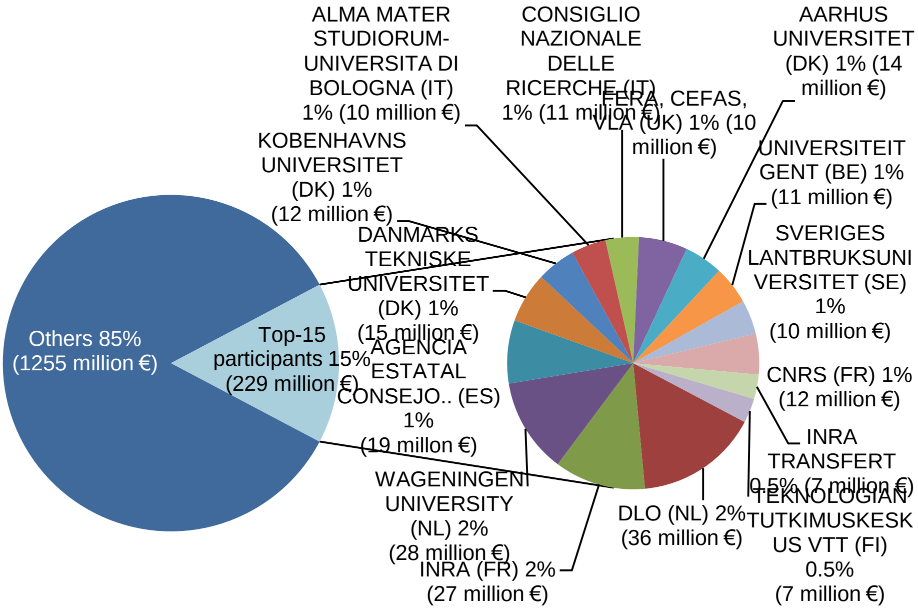

Figure 6. The allocation of funding for non-coordinating participants with the top 15 beneficiaries identified.

International organisations, federations of producers and public authorities and other mutually-owned organisations (e.g. cooperatives active in plant breeding) were also present in the consortia. Mutually-owned firms played a prominent role in agricultural research.

There are some very strongly leading players at the thematic area level. The analysis of patterns of coordination revealed that in agriculture, two organisations accounted for 26% funds for coordination and each of these also participated in excess of 40% of projects.

There was also evidence of concentration of research leadership observed in the food research where a small number of research organisations each coordinate more than 5 projects in FP7. We observed that the EU15 are particularly strong in the biological sciences with a relatively strong participation in EU12/13 countries in agricultural policy research. Some recent initiatives signal the development of regional alliances based on common geographic characteristics across EU15 and EU12/13 Member States. An example is the Network of Central and South-Easter Universities.

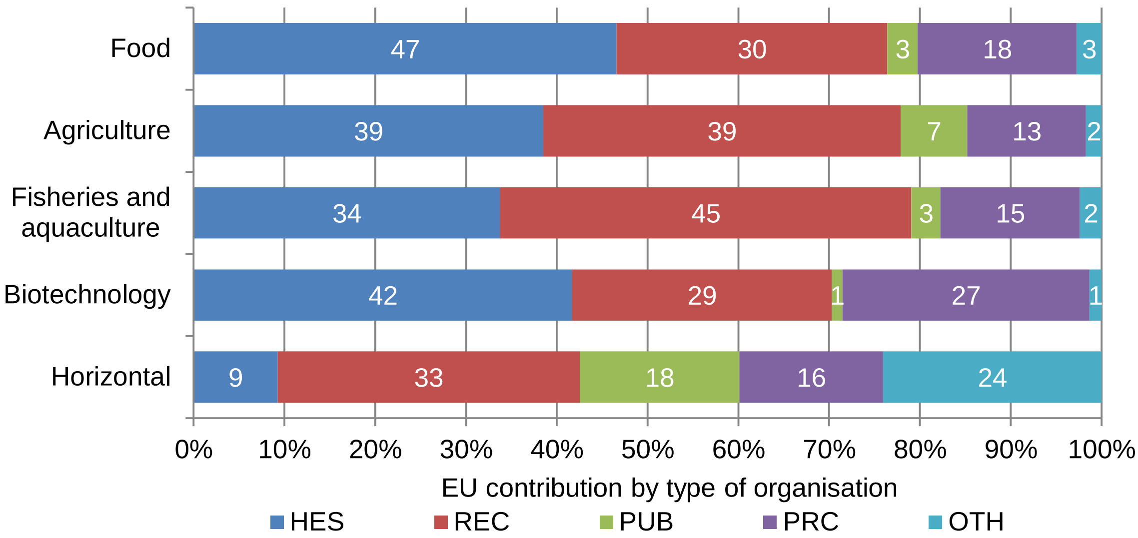

Figure 7. The partitioning (%) of the EU funding contribution to different types of organisations.

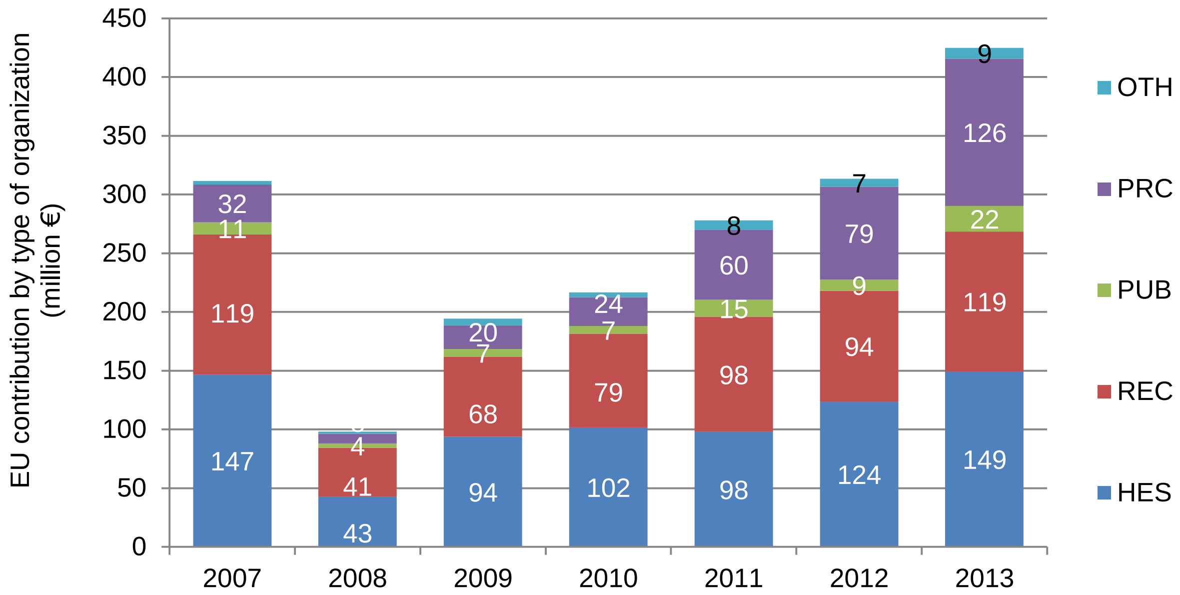

Figure 8. The allocation of EU funds to different types of participants in research projects arising from the seven annual work programmes.

Geographic distribution of participants: The geographical distribution of the project participants shows the same pattern as the statistics on coordinators. Most project coordinators for FP7 FAFB projects are from Member States (94%) and almost all of these came from EU15 states, while organisations from EU13 states coordinating 1.3% of projects (

Table 7).

Table 7. The allocation of EU funds to coordinating participants categorised by type of country.

Type of country of the coordinating partner	Projects coordinated		EU contribution to coordinating partners	
	No.	%	€ million	%
Member States (All)	485	94.3	342	94.7
Member States (EU15)	478	92.8	339	93.9
Member States (EU13)	7	1.3	3	0.8
Candidate counties	4	0.8	2	0.6
Associated countries	25	4.9	16	4.4
Third countries	1	0.2	1	0.3
Total	515	100	361	100

The allocation of funds to coordinating participants is a good indicator of the location of research leadership. Table 2 shows that by this measure, 95% of coordination efforts are located in Member States. Less than 1% of funding for coordinators goes to partners based in the EU13.

A total of 7,785 participations were recorded in FP7 FAFB projects. The EU15 States dominate participation (6,026 participations, 76%) with UK, Germany, France, Italy, Spain, the Netherlands and Belgium being most common. The EU13 account for only 8% of participations.

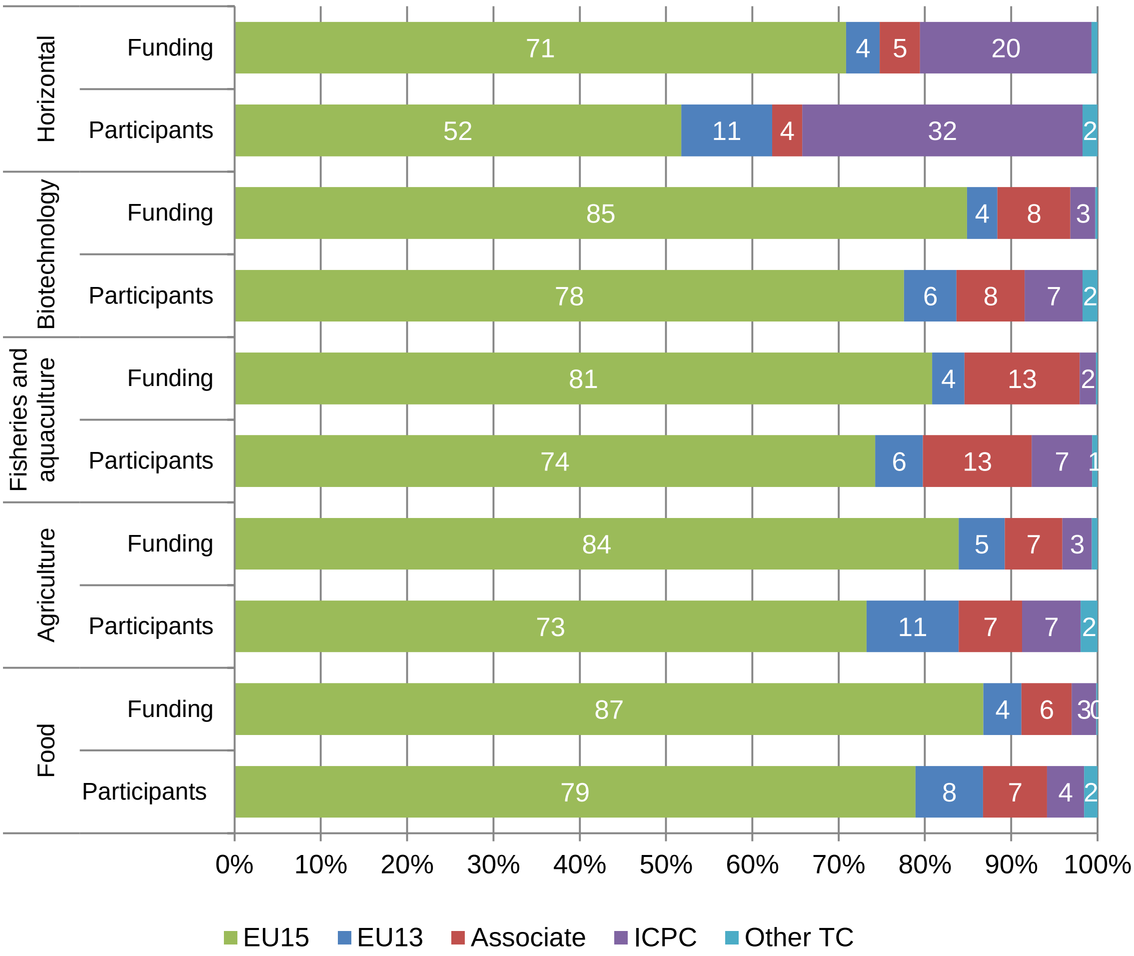

Figure 9. The geographic profile of funding and participation in the five thematic areas.

There was significant participation by partners based outside the EU: all (13) Associated Countries and 71 Third countries (ICPCs) were involved. Associated Countries accounted for 646 participations (8%), ICPCs for 641 (8%). China, Russia, the USA, South Africa, India, Brazil, Canada, Morocco, Australia, Tunisia, Argentina and Egypt were most common ICPC participants with more than 20 participations each in the FP7 FAFB projects.

There is some variation between thematic areas created by a range of factors (Figure 9). For example, in fisheries and aquaculture, maritime EU countries dominated the consortia that included 4-22 different countries with an average of 10. EU15 countries comprised 71-72% of the consortia, followed by the Associated Country members (13-15%). Norway and Israel were the most active from the Associated members in aquaculture projects. In fisheries projects, Iceland, Norway and Turkey were the most common Associated Countries.

A similar pattern was observed in the agriculture theme even though more than in other areas of science, Europe's diversity in terrestrial natural resources incentivises particularly intensive collaboration across the whole of the EU. Strong collaboration was observed between north and south with a reasonable spread of coordinators and work package leaders along a north-south axis. However, the strength of collaboration in the east-west direction is much less obvious. The EU13 accounted for 12% of participations, compared with 17% for Third Countries. The SICA and ICPC calls undoubtly had positive effect on developing third country participation, although the most dominant third country in the agriculture projects was Switzerland with 4% of the total participant number. The second was Israel, the third Norway, the fourth Turkey and the fifth China. The first African country (sixth TC) was South Africa.

In the food thematic area, the project participants were predominantly from the EU15 countries (79%); 8% were from EU13 countries, 8% from associated countries and 5% from third countries. Out of 132 funded food projects 129 projects were coordinated by organisations from EU member states, and two projects were coordinated by third countries: one project was coordinated by Norway and the other one by Switzerland. All EU coordinators were from the EU15 except for two projects, which were coordinated by participants based in Poland.

In the biotechnology thematic area, over 90% of partners were based in the EU15 countries, making it more concentrated in the EU15 than other areas.

5.5.3 ERA-NET

The ERA-NET mechanism lies at the heart of specific efforts to support the development of the ERA from collaborative research in FP7. They were initiated in FP6. In the ERA, national and regional research investment greatly exceeds EU investment, but the research effort is fragmented across national programmes. The overall objective of ERA-NETs is to identify research needs common across national programmes and to support national funding organisations in establishing mechanisms to fund these jointly from several national programmes. This burden sharing across national programmes is expected to reduce duplication and increase the efficiency of European research as a whole. The concept is an excellent complement to EU collaborative research in that it opens up access to the much larger research resource at national level and steers it towards effective international collaboration in line with European priorities. An examination of the ‘agricultural’ ERA-NETs funded in FP6 that we are familiar with showed that few if any of them have developed into fully integrated transnational programmes with common funding mechanisms (‘common pots’). In other words, they contributed little to an opening of the market for research. A significant number of ERA-NETs in FP6 were also managed by research organisations (RPOs) on behalf of the research funding organisations (RFOs) and the efficiency of funding was low – i.e. the cost to the EU of financing the ERA-NET project framework was high in relation to the volume of national research flowing through it.

Fourteen ERA-NETs were funded in FP7, including an ERA-NET Plus for organic farming and FACCE for agricultural research relevant to climate change. The ERA-NET Plus instrument supplements the national funds with EU funds. In contrast to FP6, FP7 includes some very notable ERA-NET success stories in ‘agriculture’. These include the animal health and welfare ERA-NET (EMIDA and ANIHWA) and the food security, agriculture, climate change ERA-NET plus (linked to the FACCE JPI). The ERA-NET project websites do not provide information on the volume of research funded in relation to the ERA-NET costs, but the level of activity reported indicates that it is an improvement over the ERA-NETs in their earlier stages (FP6). Governance arrangements are also clearer with programme owners (i.e. the RFO partners) taking a stronger lead, reflecting the strong engagement of SCAR in initiating ERA-NETs.

ANIHWA and EMIDA are particularly noteworthy in investing significantly in animal health and welfare research almost fully compensating for the drop in EU funding (with about €54 million). The FACCE project is also a clear collaboration between funders delivering synergies in national funding across Europe.

In food, the SUSFOOD ERA-NET resulted in a joint European Strategic Research Strategy and a research funding “organisation” in the area of sustainable food production. This organisation is already in operation with nineteen new projects started with national funding agencies jointly financing the European funding**.**

The coordination of European national marine fisheries research programmes was the overarching objective of MariFish, the only ERA-NET funded in FP6 in the area of fisheries (and one of only a few that is clearly led by a RFO in FP6). MariFish identified common research targets giving rise to a “virtual common pot” of €4.2 million for competitive research. In FP7 the ERA-NETs in fisheries matured to align with the recognised need for an integrated approach in marine production and exploitation of the seas. COFASP addresses actions that span ecosystem-based fisheries management, implementation of EU strategy for sustainable development of aquaculture and safe European fish and seafood through advanced traceability, with a €5 million virtual common pot for a first round of projects. The SEAS-ERA is seen as an overarching operational structure for implementing the European marine and maritime research agenda.

5.5.4 The open market for researchers

We see the openness of the FAFB programme as a very important contribution to European research capability and especially the ERA. Much of the public research funding in FAFB in Europe is dedicated to specific institutions (through core funding) or restricted to types of institutions (Universities and Public Sector Research Establishments). In addition, many member state governments do not fund across national borders. The Framework Programmes are unique in how they provide opportunities not only across borders but also equally to all types of research and innovation providers ranging from large national institutions through to independent self-employed scientists and service providers. The Framework Programmes are at the heart of efforts to create an open space for public research and innovation activities in FAFB in Europe. This is a general benefit of EU FP research. However, more than in many other areas of science, Europe's diversity in natural resources in fisheries, agriculture and forestry incentivises particularly intensive collaboration bringing a wide range of benefits for the ERA. We observe strong collaboration between north and south with a reasonable spread of coordinators and work package leaders along a north-south axis. However, the strength of collaboration in the east-west direction is much less obvious. Also, our observation is that EU research projects are commonly staffed by mobile early stage researchers, an indication for this is the training activities of consortia.

Transfer of these staff across borders between partners is common and a wide range of enriching effects arises from this. The governance of these projects is open and early-stage researchers get a direct insight into research management processes and strategic discussions about the direction of international research and the generation of impact. This is a significant feature almost universal in this programme but commonly missing from national research programmes. As experts, we can see that the programme has resulted in a community of agricultural, food and fisheries scientists who regard themselves as European researchers first and national or regional scientists second. They are well networked and the sequence of FPs over the last twenty years means that there is a significant community of researchers with a shared pan-European perspective. In addition, the Framework Programmes have embedded a common understanding of what a fair and open market for high quality research looks like. Our sense is that this bottom-up development of the ERA has been particularly strong in agriculture (including forestry) and fisheries, due no doubt to the international nature of the challenges.

At the project level, we note in particular the effectiveness and further potential of the projects to network completed research with users (e.g. the EADGENE ERG (European Research Group)). This illustrates the merit of maintaining projects that fulfil the function of the Networks of Excellence funded in FP6.

5.5.5 Gender equality and gender mainstreaming in research

All projects reported initial workforce statistics and the total number of staff involved is 6,647 of which 54% were male and 46% female. 1,083 additional personnel were also recruited of which 60% are male and 40% female. This results in a total of 7,730, with 55% male (Figure 10).

While participation overall is well balanced between men and women, there are clear differences in relation to leadership roles. Men are in the clear majority in leadership roles and this pattern was observed in all thematic areas. The majority (57%) of post-graduate (doctoral) positions were occupied by women.

The extent of the greater role played by men in leadership positions varied between the thematic areas. Females outnumbered males in only four of the fisheries and aquaculture projects. However, fisheries research was characterised by relatively high participation of women in leadership role compared with aquaculture. This is indicative of significant differences between research areas.

Women outnumber men in food research and occupy 38% of leading positions as work package leaders. As with other thematic areas, they outnumber men in post-graduate student positions where they occupy 66% of positions.

Clearly, the ratio of men to women increases with seniority and as the management role of positions increases. We conclude that the ratio of participation of women to men in the programme as a whole is at least as high as in wider society and that the programme cannot be expected to overcome underlying societal drivers. There are numerous underlying reasons that could be put forward. In some thematic areas, for example agriculture and fisheries, the relevant under-graduate programmes (e.g. agricultural economics) were dominated by men when many of today's senior scientists were being trained. The clear dominance of women now in the 'feeder' grades points to continued increases in women in leadership roles in the future.

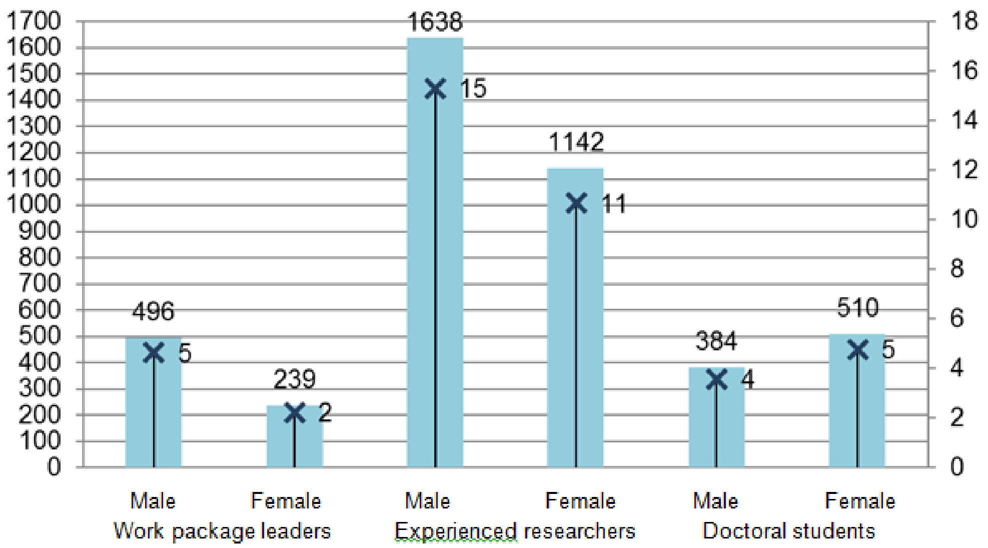

Figure 10. Numbers of male and female workers on completed FAFB projects for three levels of seniority. The blue bars are total numbers (left axis) and the x is the average per project (right axis).

5.5.6 International impacts

Ensuring that Europe becomes more competitive and plays a leading role globally through access to the best of research through international cooperation with third countries was explicitly encouraged in FP7. International cooperation always existed to different degrees among scientists but the priority given by the EC allows more efficient science and the development of a strategic approach.[39]

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[39] COM 497 (2012) Enhancing and focussing EU international cooperation in research and innovation; A strategic approach.

The EU has provided strategic support to international collaboration beyond just funding collaborative projects. Since 1990, the EU-US Task Force on Biotechnology Research has been coordinating transatlantic efforts to promote research on biotechnology and its applications. More recently, the KBBE Forum is a cooperation initiative between the European Commission (EC), Australia, Canada and New Zealand aiming at collectively addressing the global challenges such as guaranteeing food security while adapting to a changing climate, reducing the environmental impact of agriculture and industry and maintaining an affordable, safe, healthy and nutritious food supply.

The objectives for international activity are: [40]

1. to support European competitiveness through strategic partnerships with third countries in selected fields of science and by engaging the best third country scientists to work in and with Europe;

2. to enhance the production of knowledge and scientific excellence by enabling European universities, research institutions and firms to establish contact with their partners in third countries, thereby facilitating access to research environments outside Europe and promoting synergies on a global scale; and

3. to address specific problems that third countries face or that have a global character, on the basis of mutual interest and mutual benefit.

The impacts of international collaboration are complex and highly context specific. This means that a thorough assessment of the impact of the international research would require more investigation than we were in a position to do.

The definition of international as related to FP7 projects is varied. Projects can be designed as international with an international purpose of exchange. This is the case of Biotechnology project Sahyog directed towards related development in India. A project can become international because one of the partners is from one of the identified regions. The 3TO4 project is aiming at developing C4 metabolism in C3 plants which would have a major effect on global crop productivity, and one of the partners is the Chinese Academy of Sciences and the Philippines-based International Rice Research Institute. In some cases, third countries are targeted through the SICA instrument, for example, the FP7 – AFRICA – 2010 call.

International cooperation was organised within eight (8) regions. The European Union initiated projects with Asia, India, China, Africa and ACP countries, Mediterranean area, Eastern Europe and central Asia, Russia and Brazil. In total, 128 projects are reported to have a link with one or several of these regions (Figure 11). 56 agriculture projects (30%), 11 fisheries and aquaculture (24%), 20 food (15%), and 35 biotechnologies projects (30%) and 6 labelled as others were reported as “international”.

Overall, about one quarter of the 515 FAFB projects are ‘international’ reaching out to other parts of the world (beyond associated countries). Total participation from ICPCs was 641 (8%) in FP7. The top participating countries in descending order were: China, Russia, the USA, South Africa, India, Brazil, Canada, Morocco, Australia, Tunisia, Argentina and Egypt. BRIC countries accounted for 160 participations, 10 of which were SMEs.

[40] http://cordis.europa.eu/fp7/public_en.html

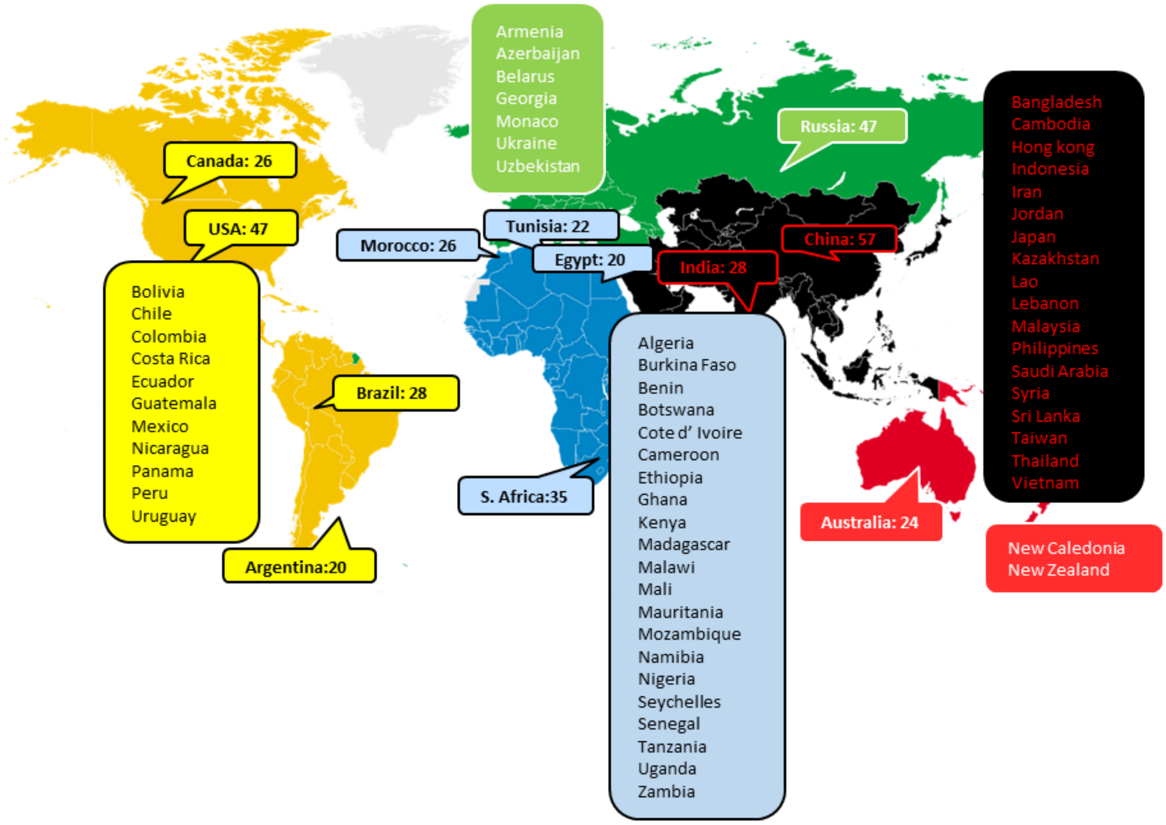

Figure 11. ICPCs participating in FP7 FAFB projects. Countries with more than 20 participations each are marked separately, along with the actual number of participations.

In fisheries research, developing/emerging countries were involved. In the case of MAREFRAME the inclusion of a research group in South Africa brings the cutting-edge expertise of that institute to Europe rather than primarily supporting development outside Europe. Two patterns in selecting the ICPCs for aquaculture projects were observed: a) the ICPC grows the same species as EU member countries and can rely on facilities (experimental, laboratories) of the same standard as EU countries, b) the ICPCs are mainly developing/emerging countries and the activity consists of developing common research approaches in both regions or in implementing research for development actions in ICPCs, in cooperation with local research, R&D and training.

The largest number of third country participation was found in projects involved with studies of food produce or products exported to the EU from third countries. This may relate to food safety questions in cereals, vegetable and fruits or to environmental issues in aquaculture. These third countries are mainly found in Asia and Africa, and typically, 3 to 4 countries are participating in the projects involved with fieldwork and providing samples for analytical studies. The projects also involved training of researchers and students for the analytical work, as well as with dissemination in these third countries. In a small number of food projects, a university or research institute from a third country with advanced own research capacity of its own is participating as a research partner with its research expertise in a specific area of the research

The twinning concept was used by Canada and Argentina to enhance collaboration with Europe. Under this arrangement countries and EU identified programmes and projects of common interests that can complement each other and benefit from exchanges of research expertise. The participants remained responsible for the execution of their research at the national level. In the case of Canada, it provided excellent twinning opportunities for research projects in support of the development of bio-based products and biorefineries.

5.6 Impact on EU policies

To evaluate the impact of the programme on EU policies it must be remembered that policy-relevant research outputs can help but not guarantee the impact of the programme on policies. To have wider impact, the results need to be used in making and implement policy. It should also be pointed out that industrial associations in the food or retail sectors, certification bodies and even NGOs also develop policies, e g for certification and labelling.

5.6.1 Food research

Quite a number of food projects were focused on policy either by developing scientific evidence for policy or legislative actions, or by providing methods for communicating to the public on health and well-being related to foods. Some results will be important for the development of the dietary guidelines in Europe and others will contribute to policy to knowledge on the effect of 'lifestyles' on the development of diabetes with possible influence on health promotion approaches.

Results of food chain related research is mainly linked with EU policy through European Food Safety Authority (EFSA) activities. The EFSA, set up in 2002, provides independent and scientific advice and communication on risks in the food chain. There are no formal links between EU research project teams and the EFSA. However a number of EU projects have provided inputs into EFSA scientific opinions (e.g. ASFRISK, CALLISTO). Either as scientific publications (e.g. peer reviewed papers or published reports) or through direct input from FP project researchers that are members of EFSA expert panels or its working groups. Nevertheless we could not find evidence in project and the programme documents that FP7 research results would have any formalised or organised link to EFSA, or any other competent organisation serving direct impact pathways between research and policy.

Quite a number of food research projects had a policy orientation either through developing scientific evidence for policy or legislative actions, or in providing methods for communicating to the public about health and well-being related to foods. Some project outcomes will be important for the development of the dietary guidelines in Europe and others will contribute studies on the effect of 'lifestyles' on the development of diabetes with possible influence on health promotion approaches. A few projects were also developing scientific evidence that may influence the legislation on health claims.

In the food safety area a number of project addressed the risks associated with both chemical and microbial contamination of foods, by providing improved detection methods and scientific evidence of prevalence in different foods and geographic areas.

Traceability and transparency in the food chain was another area where projects outcomes may influence traceability regulation. There are also more prosaic projects results related to improving the methods of sampling and the development of a number of standard foods, which could be used when the properties or components of real foods complicate the analysis.

5.6.2 Agricultural socio-economic research

The challenges and opportunities for agricultural policy research in the Framework Programmes are well described by Burrell et al.[41] In agriculture, 20 of the 38 target impact areas identified had strong policy implications. About half of the 36 completed projects have potential to impact on EU policy. The potential impacts are in a wide range of policy areas: agricultural support for production systems (e.g. 'greening of the CAP); organic farming, The

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[41] Burrell, A., Gay, S.H., M'BAREK, R. In the eye of the beholder? Opportunities and constraints of scientific policy analysis for agriculture JRC-IPTS, EUROPEAN COMMISSION.

Common Agricultural Policy in general, plant health, forest protection, and animal health and welfare.

Four agricultural research impact areas (out of 38) relate directly to agricultural policy. These are: trade, competitiveness, CAP and enlargement, and rural development. While the projects in these largely provide a basis for policy makers in policy debated issues, impact ultimate depends on political acceptance which in agricultural policy is difficult to predict and can take decades to achieve. Pathways to impact for research relevant to general agricultural policy are less formal than for research used by the standing advisory committees which draw heavily on biological research. These committees use research to address known risks (for example in plant health policy). In addition to provision of reports to policy makers within the policy-making process, there is a strong element of diffusion of evidence into the wider policy community, which in turn informs debate. An example of this is the Legume Futures project that supported a project for the European Parliament that fed into discussions about the reform of the CAP. The longer term impact of the EU's investment in agricultural policy research is that European policy now has access to a research community comparable with that in the USA. This was not the case thirty years ago (Burrell et al.). Evidence of the impact of this research in key policy processes can be seen from the evidence reported by the EC for the reform of the Common Agricultural Policy.[42] This research also has international impacts (i.e. outside the EU) through for example research on trade (e.g. AGRICISTRADE).

5.6.3 Relevance of animal health and research to policy

The provision of scientific evidence and technologies to support policy development is a particularly important research outcome in animal health and welfare. This route to impact was very effectively used, for example in case of the AFRISK project the results were used in the EFSA scientific opinion forming the basis of Commission Implementing Decision of 27 March 2014 concerning animal health control measures relating to African swine fever in certain member states (notified under document C(2014) 1979).

On the basis the programme documents, statistics and the case study analysis we fully agree with an external assessment that concluded that the EU funded research projects have made major contributions to European policies for animal health with a comprehensive portfolio in relation to policy needs. The programme has also been characterised by the anticipation of research needs in advance of these becoming clear in policy circles.[43] This is a remarkable achievement given that the programme as a whole does not provide a supporting programming framework.

5.6.4 Production agricultural research

The relevance of the development and demonstration projects is an indication of the relevance of the wider technical research to policy. More than one third of the development and demonstration research in agriculture contributed to policy making, for example to standardisation and legislation supported by communication with committees of the European Parliament, the Strategic Research Agenda 'Common Basis for policy making for the introduction of innovative approaches on data exchange in agri food industry" (AGRIXCHANGE), harmonised knowledge transfer via creation of platforms Wikipigs and Pigsci, presentations aimed at policy makers in close collaboration with ETP Food for Life (RTD2FARM).

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[42] SEC, 2011. 1153. Commission Staff Working Paper. Impact Assessment. Common Agricultural Policy towards 2020. Annex 11.

[43] European Commission 2012. A decade of EU-funded Animal Health Research. Publications Office of the European Union 213 pp. ISBN 978-92-79-21035-8

The organic farming research provides similar examples where nearly half of projects provide research-based recommendations to the EC and national competent authorities. Issues addressed included increased the effectiveness and the efficiency of organic certification (CERCOST), reduction of chemical input in crop production (EFSA, 2008) (CO-FREE), scientific data about characteristics of animal health in organic dairy farms (standards of organic dairy herds have so far not been incorporated into regulations) (IMPRO). Contributions to (EC) Nº 834/2007 on organic production and labelling of organic products, that came into force in January 2009. Underlying all this is also the fact that the development of EU policy on organic farming has been based on Framework Programme research. The latest policy initiative was the reform of the regulation and action plan.

In agriculture, research consortia organised workshops with key policy-makers and tools were provided over the internet, or as working documents for EU policy-development panels and ministerial conferences (such as the Standing Committee on the Food Chain and Animal Health (SCoFCAH), the Standing Committee on Organic Farming as well as Intergovernmental Panel on Climate Change (IPCC), the International Co-operative Programme (ICP) on forests). This is to be commended especially given the reluctance of the academic community to recognise such work in career progression.

5.6.5 Forest research

Analysis of the research on forest ecosystems and biodiversity indicates that this research has a high potential relevance to future forest policy, some of it directly relevant, for example research on the valuation of forest ecosystem services.

5.6.6 Fisheries and aquaculture

The impact of fisheries projects funded under the FP7 on the policy dimension is high and covers different fields according to the different topics addressed.

Most of the projects have or will potentially have impact on CFP. This is specifically the case for projects such as JAKEFISH and ECOFISHMAN whose aim is to involve stakeholders in jointly formulating the research and policy questions and jointly describing the approaches to address these. This will improve support and buy-in of policy. A contribution to the reform of the CFP and to the development of the Ecosystem Based Fishery Management (EBFM) comes also from MEFEPO, whose main aim is to improve fisheries management with regards to sustainability of resources, and by MADE, taking into account the capabilities offered by the new methods proposed by this project in terms of resource protection, aimed at mitigating the adverse impacts of fisheries targeting large pelagic fish in the open ocean. Even if not influencing specific legal instrument directly, also MYFISH has a high potential impact on CFP because the aim is to foster one of the main objective of the CFP (the achievement of MSY by 2015). DEEPFISHMAN, with its development of fisheries advice for the deep-sea fisheries, has certainly impacted on fisheries policy in terms of EAFM and CFP. To some extent also COMFISH will have an impact on CFP.

Some fishery projects have a major impact than others on the development of the Ecosystem Approach to Fishery Management (EAFM). In this direction is CREAM that will have an impact on the EU ecosystem policy as its main aim is to identify the gaps (in terms of data, knowledge, training, coordination) which hamper at present the full application of the Ecosystem Approach in the management of Mediterranean and Black Sea fisheries. Another project potentially impacting the EAFM is BENTHIS that will provide the knowledge to further develop the ecosystem approach to fisheries management as required by the Common Fisheries Policy and the Marine Strategy Framework Directive (MSFD).

The impact on the MSFD comes also from fishery projects such as MEFEPO or FACTS. The aim of the latter, in particular, was to develop the decision tools to assess the consequences at an ecosystem level of a given set of harvesting priorities related to forage fisheries, including their economic implications. Furthermore, FACTS has made these decision tools available where they are needed: in the ICES and STECF working groups, delivering the basics for the recommendation of harvesting strategies to the Commission. Beside impacts on MSFD, some projects will/can have impacts on the Water Framework Directive (WFD). These include SMS, SEA-ON-A-CHIP BRAAVOO, ENVIGUARD and MARIABOX considering the capabilities offered by biosensors in terms of improving monitoring of coastal areas information (water quality). The aim of these projects is to improve technology associated to sensors for marine pollution control (natural or anthropogenic) with clear implications for fisheries and aquaculture.

An impact on the Habitats Directive can come from COCONET, a large project dealing with the identification of the physical and biological connections among marine protection areas (MPAs), at regional and basin level (Mediterranean and Black Sea) to improve the knowledge on the patterns and processes of biodiversity distribution. MPAs should protect important habitats and the policy of MPA networking pursued by the project, involving also the deep sea and the connecting water body, provides a much needed knowledge platform that will be relevant for shared policies, not only for the EU member states but also for the whole Mediterranean and Black Sea regions. The project is expected to contribute also to the development of EU Marine Spatial Planning in the Mediterranean and Black Seas. There are also fishery projects impacting on the EU control policy, such as FISHPOPTRACE. The impact can come from the traceability tools (validation) and standard procedures developed by the project. This is demonstrated by the high interaction between the project and EU bodies (DGMARE, EU Control agency and relevant stakeholders) dealing with traceability issues as well as fighting against IUU fishing. Furthermore, the FISHPOPTRACE team has participated twice in the public consultation for the definition of the new CFP.

Some projects may have an impact on the external dimension, specifically on Fisheries Partnership Agreements, such as TXTOX. The main impact is on the CFP. Policy is based on assessment of data and the main aim of TXTOX is to strengthen the knowledge base in support of policy making, in the specific case to support the policy instruments dealing with international agreements on the use of fish resources (UNCLOS, CCRF, UNIA, WSSD) by collecting data from the main RFMOs.

The impact of aquaculture projects on EU policies varied greatly according to the nature of the project. In general, projects with a great deal of basic research are expected to support practices and regulations within the pillar “Better framework for aquaculture” of the reform of the Common Fisheries Policy in coming years by supporting strategic decisions on species selection (DIVERSIFY), domestication (FISHBOOST) and seed validation (REPROSEED), disease prevention and safety regulations (AquaInnova, PROMICROBE), introduction of welfare indicators (COPEWELL), management of natural resources by moving away from capture-based aquaculture (PRO-EEL, SELFDOTT, TRANSDOTT), traceability of wild vs farmed individuals (SELFDOTT, AQUATRACE). The latter projects (PRO-EEL, SELFDOTT, TRANSDOTT, AQUATRACE) have also the capacity to contribute to environmental protection under the Marine Strategy Framework Directive (MSFD) since they are relevant to the descriptor n°1 on biological diversity as well as descriptor n°2 on non-indigenous species. Similarly, traceability of products has become a specific request of consumers, sustained by national and European policies. Genetic tools developed or under development offer cost-effective strategies for supporting quality plans, enforceable by law where required, aiming at tracing and monitoring the origin of aquaculture products.

5.6.7 Biotechnology

In biotechnology, a number of projects were relevant to policy through developing scientific evidence for policy or legislative actions with some focus on communication with the public. Other projects yielded scientific data to support the development of guidelines, standards, standardisation and legislation. There were projects directed specifically to policy making. Two out of the 27 industrial biotechnology projects specifically addressed policy issues and two more identified policy issues. Several projects are likely to produce data useful for defining standards.

5.7 European added-value

European added-value is closely associated with impacts on the ERA. European value added is about research performance and impact that arises from the European approach additional to that that can be achieved by other mechanisms, particularly national funding. European added value also has a social dimension: indirectly, and more strategically, the FAFB programme contributes added value in Europe by supporting the sustainable production and processing of food that is healthy and contributes significantly to the high living standards of the European citizens.

It is clear that the FAFB programme represented a very significant intervention in the market for this type of public research in Europe. Despite the large sum invested, it was a relatively small part of the total public investment in this type of public research across the EU. National programmes still dominate in funding terms. This raises the question of the rationale for continued EU level investment. This question comes into sharper focus where development depends in part on the development of regional solutions for regional conditions. The ultimate argument for EU investment is it adds value to the European Research Area that cannot be added at national or regional level. Our assessment of the impact of the Framework Programmes concludes that EU funding not only adds value to research areas that cannot be currently be added by member state based programmes.

5.7.1 European evidence for European policy

EU legislation and regulation requires evidence generated from a European perspective. Research supporting the formulation of guidelines, legislation and policies applied at EU level in the area of agriculture and rural development needs to be coherent and consistent at EU level. Animal and plant health policy also needs access to a coherent European knowledge base and scientists who work at European level. Experience indicates that in practice only the EU is in a position to drive investment in such European research. The programme is clearly impacting on the European policy community and the Framework Programmes have been instrumental in raising the standard of evidence-based policy development in agriculture and fisheries.[44]

5.7.2 The ability to invest in international research

Generally, most existing national programmes prevent pooling of funds and investment in research across national borders. It could be argued that such pooling of national funds is possible thus providing an alternative to EU funding. However, experience shows this has proved practically impossible. Our analysis of the ERA-NETs shows that despite the excellence of the idea and the obvious benefits for national funding bodies, ERA-NETs have so far largely failed to get national funders to pool resources within common funding mechanisms. So the goal of bringing together national public investment in an open and international market for research remains remote. Direct investment on the part of the EU is still the only means of investing public funds coherently in research at the European level.

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[44] Burrell, A., Gay, S.H., M'BAREK, R. In the eye of the beholder? Opportunities and constraints of scientific policy analysis for agriculture JRC-IPTS, EUROPEAN COMMISSION.

[44] SEC, 2011. 1153. Commission Staff Working Paper. Impact Assessment. Common Agricultural Policy towards 2020. Annex 11

The resulting collaboration between researchers and the pooling of resources across national borders has huge implications for EU research capability. Through the Framework Programmes, research targets that require large-scale investment or that address problems that extend across national borders can be undertaken relatively easily. For example, it is noted that food projects use extensive fieldwork using cohort studies, specifically designed questionnaires, etc. This kind of research is very expensive and time consuming, and could hardly be executed on the same scale outside of the setting of a FP7 project. Also bringing together national cohorts from many EU countries as done in the EFRAIM project and thereby providing a better foundation for the research finding is a very clear European added value.

Certain technologies are also best developed on the European scale. The genetic improvement of key species is just one example.

The size of investment in aquaculture research in FP7 has reinforced the European scientific foundations and supported the international reputation of European scientific community as global leader of aquaculture research. This reputation facilitates the outreach of European researchers to other parts of the world, where aquaculture initiatives seek consultancy and this supports the expansion of European aquaculture industry. At the same time, FP7 outcomes have been moulding strategy, regulatory frameworks and policies that place EU at the forefront of international developments and secure high production quality standards. FP7 actions have supported environment- friendly industrial practices and have taken a step forward to promote the idea of sentinel monitoring of the aquatic environment. It is evident that the size of intervention during FP7 could have been achieved only at EU level and would not be tangible at national level. All these are translated in revenue for European companies and quality of life for the European citizens while creating a distinct, overarching EU trademark for the aquaculture industry.

5.7.3 Integrating research approaches

The European research system in any one research area is not only fragmented by national borders, it is also fragmented within countries, particularly in terms of the OECD's Frascati scale.[45] The EU programme is the only large programme that funds research right across the Frascati scale from basic through to applied experimental development. In addition, EU funded research can extend to near-market development and provide direct benefits to participating SMEs.

5.7.4 Leverage effect in promoting national research efforts

Although not mentioned in any documents, it is known that national research programmes are much influenced by the EU framework programmes, e.g. the Strategy for Food Research in Sweden. To this may be added a number of Strategic Research Agendas for particular areas are being developed in some FP7 projects e.g. for traditional foods and for sustainable foods.

In agriculture, a very significant proportion of national research investment is provided through core funding of public sector research establishments. This applies for example to France and Germany in particular, and also to Italy and Spain. This means that it is difficult to assess the leverage effect on national funding as any effect would not be manifest in

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[45] OECD 2002. The measurement of scientific and technological activities. Proposed Standard Practice for Surveys on Research and Experimental Development (Frascati Manual)

discrete projects. There is some evidence that national programmes are levering EU funding (e.g. TriticeaeGenome).

FP6 made significant investment in zoonosis research and this was reduced in FP7, particularly from about 2010 onwards. It is noticeable that this coincided with a decision by a consortium of UK research funders (mostly Research Councils) to invest about 20 million Euros in zoonosis research with emphasis on developing countries.[46] We can speculate that previous EU investment in that area helped to create capacity that is now benefiting from the UK programme. Related to this, we note the extraordinary success of the ERA-NETS in animal health and welfare (EMIDA and ANIHWA). Member states have invested more than €50 million in international research in these fully compensating for the EU's reduction in this area. Other ERA-NETS are also showing this effect but it is impossible to more than speculate that the effect is additive.

The limited information about member state's expenditure on research does not allow for an exact comparison with EU spending. What can be observed is that FP7 funding encourages cooperation among EU member states, helping to establish international research networks. In the evaluation on animal welfare research the interviewed stakeholders found strong similarities and some overlap with research topics of EU projects.[47] Thus there is room for harmonising of research efforts within and between individual EU countries where there could be a positive role for the EC as the exchange platform of research information across Europe. This may be one of the roles for a network of European Reference Centres or Centres for Excellence each specialising in an important issue. It could be modelled on the existing network of Community Reference Laboratories (CRLs), in this case the network helped to harmonise diagnosis and control of relevant animal diseases in the EU.

[46] Zoonoses and emerging livestock systems (ZELS): reducing the risk to livestock and people.

[47] GHK in association with ADAS UK (Food Policy Evaluation Consortium): Evaluation of the EU Policy on Animal Welfare and Possible Policy Options for the Future, DG SANCO, Final Report, December 2010

6 Conclusions and recommendations

An assessment of impact of a programme that is not yet complete is necessarily a predictive exercise. We used the existing or expected outputs as a basis for assessing what their collective impact might be, all in relation to the programme's societal goals. In addition to examining the performance of completed projects, we examined the EC's plan as set out in the annual work programmes (calls) and resulting project plans. This partially overcomes the lack of ex-post project information that is inevitable in a programme that is still on-going.

The Framework Programmes have a particularly high profile in the agricultural, forestry, fisheries, food research and biotechnology and related policy communities. In reflecting on the performance of the programme, we need to consider the funding context. This programme covering the entire terrestrial primary resource base (agriculture, forestry, fisheries and aquaculture as well as broader terrestrial and aquatic resources), and the post-farm sectors in food and non-food (including research for consumers and bio-based industries) had an average annual budget of approximately €262 million. This is comparable to the investment in corresponding goal-oriented research made at national level by just one medium to large member state. The programme is large enough to influence the science and innovation base, but not to dominant it comprehensively. Considering the scale of funding, the FAFB research in FP7 has high impact potential.

6.1 Rationale

In drawing conclusions about how well the work programmes addressed the main societal goals, it must be emphasised that the annual work programme documents do not set out the EC's rationale for the research in any detail, except within individual topic descriptions. The goals set out at the programme level are broad socio-political and economic goals. Individual topics set out required project research outputs and outcomes in varying degrees of detail and specificity. Between these, there is no real science-based operational framework or research strategy. For example, very substantial sums were invested in major targets (e.g. research supporting plant breeding) without a rationale, guiding programme framework, or research policy at this level. This lack of a science-based framework is likely to jeopardise the targeting of resources, the fostering of synergies, and the pursuit of impact targets over time. To overcome this, programme managers intervened at project level on a case-by-case basis in some areas to obtain some of the synergies and complementarities between projects that come from programming.

As a result there of the lack of a strategic programming framework, there is a lack of information on research targets above the level of individual projects. We therefore describe the programme rationale using the background information provided in topic descriptions and brief descriptions of the 'context' in annual work programmes combined with our own understanding of drivers. These research activities support Europe 2020 but were established before Europe 2020 was developed.

The food research covers a fairly clearly framed set of research activities using 27% of EU FAFB funds. From a policy viewpoint, the research is very diverse ranging from topics of clear public relevance and subject to profound market failure (e.g. research on eating disorders) to research with almost exclusively private benefits gained within valuable privately owned supply-chains (e.g. food processing). In the 'context' part of the 2007 and 2008 work programmes that introduced FP7, this very broad range of strategic outcomes is covered in just one sentence. Looking at the individual topics (projects), we can identify some common drivers relevant to Europe 2020 and related goals: improving diet, tackling eating disorders and diet-related illness; improving the efficiency and economic performance of food processing; reducing food-borne health risks; and supporting understanding of food system resource and environmental impacts.

The annual work programmes indicate a link between support for new "high-tech eco-efficient processing and packaging systems" and increased number of patents and new market opportunities exploited by SMEs. This is the implicit rationale for allocating 7% of all EU funds to food processing research. The relevance to Europe 2020 is through the economic effects of adding more value in food processing, but this thinking is not explicit.

Research on the primary resource base accounts for 48% of EU funds (31% in agriculture and forestry, 9% in fisheries and aquaculture, and 8% in biotechnology). The emphasis on supporting and protecting primary production (farming, forestry and fishing) is a major strength of the programme. FP7 restored research in primary production, signalled by the use of the word 'agriculture' in the title. As a result, research in FP7 is much better matched to the needs of Europe 2020 than the corresponding research in FP6, which was focused on food safety and quality, and consumer-related questions. The investment in farm production research in FP7 was a milestone in restoring European production agricultural research which had until then steadily declined in Europe from about 1980. Thus, a number of agricultural research themes that are very relevant to Europe 2020 goals emerged strongly in FP7 and were pursued at project level. Improvements in biological resource-use efficiency lead to net gains that flow through the supply chains, ultimately leading to lower food prices, improvement in the trade balance, or opportunities to use biological resources in other ways such as ecosystem protection or the expansion of the bio-based sector. Complementing on-going themes such as animal health research, the research supported plant and animal breeding, improvements in farming systems, and control of production diseases of animals. In addition to supporting production improvement with a wide spectrum of strategic and applied research, there is also a significant investment in 'enabling' research that seeks to draw on basic biological research, particularly molecular biology that has expanded greatly in recent decades. A significant proportion of this enabling research and some of the production research in agriculture is highly speculative and at the basic end of the Frascati scale. It is unlikely to deliver direct impacts other than those on science. There is relatively little emphasis on biodiversity outcomes, especially those that depend on whole-farm or landscape-scale action.

In terms of societal goals, the fisheries and aquaculture research has much in common with agriculture and forestry. It is driven by the need to sustain and manage primary biological resources effectively. Our assessment is that the fisheries and aquaculture programme in particular reflects a deep understanding of the current challenges and is focused on these. Agriculture and fisheries both have strong policy dimensions. In both agriculture and fisheries there are trade-offs between resource or wider environmental protection/animal welfare and economic outcomes, particularly in the short-term. This is most clearly seen in fisheries where the use of research results will reduce fishing activity and employment in the short term.

The biotechnology activity is the largest of the activities in terms of EU funding (32%). It mostly relates to the bio-based industries.[48] The proportion of FAFB funds in annual work programmes going to biotechnology increased significantly from 24% in 2007-2008 to 41% in 2012-2013. The scale of this investment in relation to the current economic size of the target sector is not discussed in the annual work programmes, but we assume that this is justified by a 'new frontiers' argument. In contrast to the other three thematic areas focused on distinct user communities, the biotechnology activity is focused on specific technological approaches. We found it difficult to identify a clear rationale for this approach to research for the bio-based sector and we identified a number of strategic weaknesses. Particularly in the area of biorefining and industrial biotechnology, research on tools and processes was initiated without first looking at what are the most promising value chains and what change is required to support these. The biotechnology thematic area as a whole is unclear with respect to the relative roles of strategic research that supports wider understanding underpinning innovation in the longer term and applied research to support product development. The research projects themselves were effective in generating new

[48] Clever Consult, 2010. The knowledge-based bioeconomy in Europe: achievements and challenges.

knowledge and there are notable successes such as in the plant-based production of vaccines.

With the exception of some research into primary biomass production, which declined as the programme advanced, the biotechnology research relates closely to post-farm supply chains in the bio-based industries and therefore mostly to private goods. There is a clear expectation of a rich yield of intellectual property relevant to reducing dependence on fossil energy sources.

Overall, we conclude that the FAFB research activities are well matched to the social goals they serve. As would be expected in any programme of this size and complexity, there is scope for improving the prospects for impact. Reservations relate to the science-driven nature of some of the research (especially enabling agricultural research) and the lack of an explicit rationale for some interventions.

Considering the modest funding in relation to the Europe-wide challenges addressed, we note that the breadth of activities undertaken in projects, in response to diverse EC requirements expressed at programme and project level, is a potential weakness. This does not mean that the scope of the programme is too broad. What is meant is that within that broad scope, individual projects seek to address too many programme objectives. Linked to broad bottom-up stakeholder driven processes, the programme is trying to do too much and this is reducing focus on key targets and impacts. Many of the call 'topics' offer 'bottom-up' (non-prescriptive) research opportunities to the extent that the main research goal is left to applicants to decide but at the same time consortia are required to address numerous conditions. These include requiring that a minimum of project funds be allocated to SME partners without an obvious rationale in many cases, and requirements to address several ancillary targets that dilute the attention to the main target. The end result is a set of projects (rather than a programme) with each ranging widely and unpredictably in the research space. This was noted in agricultural research in particular. This broad, 'bottom-up' non-prescriptive approach continues in Horizon 2020. There is evidence of forced SME participation to reach funding targets in some areas (e.g. fisheries). In a significant number of projects, the SME partners are not driving the research or playing a leading role in generating impact. In contrast, internationalisation of research progressed smoothly with promising beneficial effects. This is partly due to the international nature of science and to the recognition by scientists of the international nature of the challenges.

Compared with FP6, investment in research at the basic end of the research spectrum was increased (with some of it focused on basic biological processes) while at the same time investment at the other end in development and demonstration was initiated. Investment in forestry research was restored. These are all in principle positive developments, but there are risks when the scope of a programme expands without efforts to address priority targets in a managed way. This is particularly relevant given the lack of an explicit science-based programming framework.

The programme is clearly responsive to political signals, implemented largely at topic (project) level. However, the programme addressed some research themes late, in some cases after corresponding national research was well advanced or completed. An example is research on dairy cow fertility. Some of this may be due to the block on production oriented agricultural research and nearly all forestry research in FP6. In general a programme management system that is so focused on responding to diverse stakeholder input in managing the establishment and contracting of individual projects is always at risk of following rather than leading opportunities.

6.2 Implementation

The research projects are thoroughly managed (by both the EC and by consortia), and they generally achieve their objectives. The project plans are characterised by commitment to delivering research outputs to a wide range of users by means of peer-reviewed publications, conference participation, and engaging with a range of other users using a wide range of means, including direct contact with key users such as policy makers. There are numerous examples of projects of international standing delivering research of practical significance in a way not possible with national funding. There is also a commitment to a combination of scientific and wider societal impact that is rare in national or private sector research. The programme is supporting broad-based effective consortia and the commitment to collaboration is clear.

The EC's programme managers have been remarkably successful in meeting programme management goals. It is evident that the drafting of individual topic calls, rather than area or programme-level measures, was the main means of delivering on these targets and this contributed to the 'trying to do too much' risk discussed above. There is evidence of some rather simplistic research management ideas behind some implementation approaches, for example that non-prescriptiveness fosters innovation.

There was emphasis on pluri-disciplinarity, and projects generally combined a range of disciplines. But there was some variation in the depth of this pluri-disciplinarity. For example, the fisheries and aquaculture research sometimes had relevant social-sciences questions addressed by people not formally trained in the relevant disciplines. In projects originating from the 2007-2010 work programmes, a number of social science investigations were carried out by biologists with some relevant social science knowledge. This changed, and projects from later work programmes (from calls in 2011 onwards) included specific social sciences work packages led by specialists in this field.

With only 14 exceptions, coordinators of FAFB projects were from the EU15 countries. The project participants were predominantly from the EU15. 8% were from the EU13, 6% from associated countries, 2% from candidate countries and 8% from ICPCs.

Within the EU15, there is some evidence of concentration of leadership in relatively few research organisations. More than a quarter of the research in the agriculture thematic area (in funding terms) was led by either INRA or institutes associated with Wageningen University. They led also in terms of non-coordinating participation with each involved in 40% of agriculture projects.

Where data allowed, we assessed the effort put into contract administration (as distinct from research coordination). Where they are used, partners that provide contract administration services generally account for 0.5 to 1.0 of an employee on the project. This is a substantial resource dedicated just to administration. Despite the effort put into administration, the quality of formal reporting to the public is very variable. The EC's publishable summaries of final reports provided to us are constrained in what can be presented (text only) and not fit-for-purpose. The result is the records of projects are either usually fragmented in the scientific literature or are temporary on project websites. Efforts to simplify contract procedures have had only a marginal effect, but positive. The goal of trust-based administration focused on research outcomes rather than research inputs implicit in the Lund Declaration[49] is some way off.

6.3 Impact

Six broad target groups of end-users of research can be identified. These are:

- farmers, foresters, fishermen and other primary producers in supply chains;

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[49] Swedish Presidency of the European Council. 2009. The Lund Declaration. Europe must focus on the grand challenges of our time.

- technology providers, the service and input supply sectors, e.g. breeders, forest management planning services, fisheries management bodies;
- the food industry, related health professionals, NGOs and consumers;
- the non-food bio-based industries;
- policy-makers; and
- other scientists

The range of primary users of food research outputs is particularly diverse reflecting the diversity of strategic goals behind the research. The primary users of 'public good' consumer and nutrition research are the research community who inform consumers and the food industry. The food processing research impacts on the food industry directly, while research relevant to food safety is delivered mainly through regulators and other public agencies. Of particular interest is food systems research which impacts on a wide range of users including organisations interested in corporate responsibility.

There also indirect and intermediate beneficiaries. Consumers in general are an indirect beneficiary of research, particularly research on organic farming, animal health and welfare issues, and from food research on eating disorders, infant nutrition, and on foods for specific groups. Educators and students are indirect beneficiaries of all the new knowledge generated.

High impact on science is characteristic of all parts of the programme with a strong commitment to communicating results to other scientists through the academic press. Related to impact on science, there is significant impact through education evident from the staffing of projects with early career scientists, although this outcome in terms of post-graduate training is often not explicitly reported.

We identified significant decisive technological impact on Europe 2020 in research addressing the protection and exploitation of biological resources – farms, fisheries and forestry. This includes the control of notifiable animal diseases, plant diseases, treats to our forests and the value of forest ecosystem services, and in socio-economic research supporting the CAP, the CFP and related policy areas. The programme also provides strategic support to the development of key technologies in plant and animal breeding with a wide range of research projects bridging the gap between basic molecular biological knowledge and its practical application by breeders. A special feature of the agricultural research in FP7 is investment in farming and agricultural systems studies which simulate systems innovation that is essential if the foundations of a more resource-efficient agriculture are to be formed. The programme is making a difference to Europe in these areas but many of these technological impacts cannot be quantified or assessed by conventional measures of commercial innovation.

For the projects already completed, about one fifth of consortia have taken out at least one patent with a total of 52 patent applications from 107 completed projects. Most came from the biotechnology research areas. This is 6.2 patent applications per €10 million invested although this is a crude measure when there are other forms of exploitation which are effective such as copyright, design rights, plant breeders' rights, trade secrets etc., in addition to exploitation out of the public domain. Much of the research could be considered as 'enabling' and will produce results relevant in the future. Research outputs that have the potential to lead to tangible commercial impact were commonly noted in all four main thematic areas.

Even though our assessment is made while much of the research is ongoing, we can see there is commitment to a wide range of impacts through investment in people. Through successive programmes of research, which in the case of agriculture go back to the establishment of the CAP following the Treaty of Rome in 1957, Europe now has direct access to a research and innovation community for which international collaboration is second nature. International collaboration at this level requires effort that goes well beyond the effort researchers put into setting up national or even bilateral collaborations. This is a significant underlying achievement that can be easily overlooked. This research community is well integrated right across Europe with increasing participation from new member states as the EU expanded, and is also committed to interaction with a wide range of users.

Despite the significant effort made in reporting to the EC, reporting in general is very variable and focused on reporting to the EC for contract purposes. Access to many outputs such as those provided on project websites declines after the end of the project.

Our short analysis of the evolution of research in the Framework Programmes reveals a fairly steady development from funding research led by researchers up to FP4. From FP4 onwards, there was increasing emphasis on wider societal relevance and impact, encapsulated in phrases such as 'Quality of Life' (FP5), 'Fork to Farm' (FP6) and the 'Knowledge-based Bioeconomy' (FP7). The increased emphasis on social, economic and environmental impact is clear. However, the programme remains essentially about funding research driven largely by the academic community with the EC focused on managing research contracts. The criteria for assessing impact in project proposals focus on researchers' descriptions of the relevance of their research to the expected impacts set out in topics and the efforts to 'disseminate' results. There are few examples of a strategic approach to developing impact that would be expected in research led by innovators. SME partners generally describe themselves as providers of science services and there are few examples in the projects we examined of conventional privately-owned SMEs describing themselves as potential users and developers of research outputs. Some SMEs are mutually-owned, for example cooperative-type enterprises or societies support animal breeding. Particularly in agriculture, these types of private sector partners can be very effective agents of innovation, but not necessarily using patents.

There has been rather simple blanket reliance of some features and mechanisms. Successive Framework Programmes have increasingly emphasised the role of SMEs to the point where funding of SMEs was required in many projects in the later stages of FP7. Private sector involvement in research is valuable in many circumstances, particularly where the main research outputs support new commercial products and processes. In these circumstances, the private sector could play a role at levels higher than 25% in research projects. Some research outputs, for example new vaccines, require levels of investment in development that are beyond the reach of most SMEs. It should also not be overlooked that involving private interests in research consortia risks blocking public access to the same outputs of public importance. There are also many situations where the private sector has a collective interest in research that is not effectively served by the involvement of individual SMEs. Much of the knowledge and understanding used to innovate in agriculture, forestry, fisheries, aquaculture and food is a public good in itself. It is encouraging to see that some research consortia have satisfied the SME requirement by using organisations that have a strong collective or mutually-owned character, such as mutually-owned breeding enterprises.

Another common approach to impact is to integrate research at the project level along supply chains. The thinking seems to be that if a project addresses a series of challenges along the relevant supply chains, then linkages relevant to exploitation will follow. It is a notable feature of agriculture and biotechnology research in particular. This is simplistic and contributes to a lack of focus on key targets. The associated addition of requirements expressed in call topics leads to topic requirements which are unclear. As we have seen in case studies in the agriculture thematic area, the outcome of non-prescriptive topics with requirements to integrate research along supply chains is unpredictable in terms of impact on target areas. There is a risk that a combination of non-prescriptiveness and ambiguity of topic requirements supports leading programme participants who are in a position to participate in several proposals in a single topic competition.

6.4 Opportunities

This research community now has a stronger sense of purpose than it did when FP7 started arising in particular from the realisation in the wider policy community that biological resources (esp. fisheries, agricultural and forestry) are scarce. In the case of fisheries, they are also now very vulnerable. The EC also now has access to an active Standing Committee on Agricultural Research (SCAR) revitalised following European Council decisions in 2004 and this is providing advice relevant to all FAFB areas. Some of the ERA-NETs funded in FP7 have been extraordinarily successful and this collaboration between national programmes provides the EC with an opportunity to focus its own research resources on playing a managed central role.

There is also clarity of purpose emerging in policy with the latest reform of the CAP (2014 – 2020) and the reform of the CFP. Through 'greening', the principle of public goods for public money has been established in the agricultural community and this offers opportunities to develop existing research concepts about agro-ecosystems. The CAP reform also includes a clear commitment to science-based innovation through the European Innovation Partnership which has the potential to revolutionise the pathway between EU agricultural research and farm practice. Fishing at maximum sustainable levels, under multi-annual ecosystem-based management under the reformed CFP, offers more opportunities for the application of research results.

There is also the hope of stability due to the lessons of the past. The results of research in FP6, which de-prioritised production and environmental research, came on stream just as the policy community became most aware of the importance of production and resource-use efficiency, and when environmental protection was moving to the centre of the CAP ('greening'). This provides a lesson about the need to actively manage the miss-match between research investment and political cycles. 'Breaking with the past', successive Framework Programmes have been developed with a focus on immediate political concerns of the day and with insufficient consideration of past outputs and their relevance to longer term needs. Delivering impact for 'Europe 2020' and 'Innovation Union' and 'Resource efficient Europe' will depend on how research is focused coherently on key research and innovation targets.

Overall, this is a much more positive environment compared with that which was prevalent during FP6 when FP7 was prepared. For investing in the applied research, the EC can have increasing confidence that the biological sciences, for example molecular genetics, are now delivering real opportunities for applied research. The combination of high-throughput technologies, bioinformatics and modelling provide a rich resource on which to build effective applied programmes that can benefit in particular from international collaboration.

6.5 Challenges

The overriding research priority is the continuing restoration of research relevant to the management, protection and use of biological resources with efforts to focus on and reward wider delivery of impact from that research. The output of farms, fisheries and forests forms the foundation of €1.5 trillion per year turnover in the European economy. While the EU's FAFB research programme is small compared with the sum of national programmes, and small considering the size of the economic target and the natural resources covered, it remains the only programme that can provide integrated and integrating leadership at the European level. The programme must be more than a collection of funded research projects, no matter how good these projects individually might be. Positioning and managing the programme to provide this central leadership and to add value to the national programmes is a key research policy challenge.

The impact of this research depends on what happens on European farms, forests, fisheries and in the related supply systems. Food, agriculture, forestry and fisheries are very intertwined with public goods and policies and are different from most other parts of the economy. The know-how and techniques used in primary production are frequently based on public domain knowledge and technology; and the performance of complex biological, economic and social systems has an important role to play in determining outcomes. Even proprietary technologies such as improved plants or animals for breeding have a strong public good character. It would be a mistake to expect that research and innovation paradigms that operate in, for example, pharmaceuticals or aeronautics can deliver significant wealth here that has so far been untapped.

A combination of diversity and scarcity of natural resources is a defining feature of European agriculture, forestry and fisheries. The diversity, for example in the wide range of crops grown, also means there is a greater degree of market failure for key research outputs such compared with competitors such as the United States or Australia. The EU FAFB research fund is significant but small considering the scientific, economic and geographic range it covers. This means that strategic prioritisation is required to ensure that this public EU investment complements other efforts, especially those in the private sector.

6.6 Recommendations

Rationale

1. We recommend that the EC uses more pro-active research programme management, in particular at a level of aggregation directly above the level of projects. This focuses on identifying in science terms what needs to be done, who needs to do it, how and why it will be resourced. This can partly replace the current emphasis on management at the project level and complement 'bottom-up' demands with 'top-down' science-based strategic direction. The resulting project aggregations or portfolios (not just the specific research projects or 'topics') need to be designed by the EC so that they are coherent in both policy and in science terms and the EC needs to be the driving force behind them, not just a conduit for stakeholders' needs and a funder of research that has been driven or defined by others. This will lead to greater transparency about the scientific directions being taken and the use of funds. A strategic science-based programming system can be designed to respond appropriately to short-term political aspirations while fostering the flexibility of a strong research base that enables that responsiveness.

Adopting strategic research programming at this level is a skilled and demanding task that requires deep scientific understanding of the research and impact areas targeted. It establishes in advance the research and innovation objectives at the programme level supported by the assessment of the current research and development status, and the development of pathways through which the research objectives can be reached.[50] [51] [52] [53] [54] [55] Strategic planning is particularly relevant in the context of this programme because of the goal orientation and because of the potential central role in relevant European research

[50] Academy of Finland (2009). Academy of Finland Research Programme Strategy. http://www.aka.fi/Tiedostot/Tiedostot/Julkaisut/tutkimusohjelmastrategia09_210x280_ENG.pdf .

[51] Feed the future (2011). Feed the Future: Global Food Security Research Strategy. http://pdf.usaid.gov/pdf_docs/PDACR702.pdf .

[52] CGIAR (2011). A Strategy and Results Framework for the CGIAR. (http://consortium.cgiar.org/wp-content/uploads/2011/08/CGIAR-SRF-Feb_20_2011.pdf)

[53] Byerlee, D. / Alex, G. (1998). Strengthening National Agricultural Research Systems. Policy Issues and Good Practice. The World Bank. Washington, D.C.

[54] Furman, E. et al. (2006). Experiences in the management of research funding programmes for environmental protection. Including recommendations for best practice. Finnish Environment 43/2006. Helsinki.

[55] IWRM-net (2008). Proceedings from the IWRM-net research Management Workshop. A good practice guide.

http://www.old.iwrm-net.eu/IMG/doc/Proceedings_IWRMnet_research_management_dec08_V3-3.doc areas. The resulting framework allows synergies between projects to be actively and transparently managed, progress in relation to science outcomes monitored at programme level, and emerging gaps and opportunities to be identified and addressed in systematic and targeted way. It also provides a transparent framework for the inclusion of stakeholder inputs. The overall effect is to raise the focus of research leadership (both in the EC and within stakeholder groups) above the level of individual projects and focus it on higher level research and innovation outcomes and their relationship to societal goals.

2. We recommend that there be a degree of continuity between Framework Programme 7 and Horizon 2020. Linked to scientific coherence that strategic science programming would support, the EC needs to ensure that there is an adequate balance between research activities directly linked to the main societal challenges and the needs of an underpinning research base supporting this. Such a supporting research base increases the ability to address unknown future challenges. FP7 was innovative in how it used projects to investigate new research areas and supported research policy development. At the same time, other (also small) projects focused on developing and demonstrating outputs from completed research. This is an example of the development of an effective mix of project approaches. The use of development and demonstration projects should be expanded, either in the collaborative research programme or elsewhere.

3. We recommend that the EC revises its policy on SME involvement in research. Private sector involvement in research is often very valuable, particularly where the main research outputs support new commercial products and processes. At one level it can result in economic considerations driving research. At another level, it can result in science driving new commercial opportunities and markets. SME participation should be based on the nature of the research questions, research outputs and the impacts sought and should not be a general or even common requirement. Many areas of research related to public goods or where the research output is a public good are not amenable to private sector involvement. Other areas such as food processing relate strongly to substantial private economic benefits and in these much higher levels of SME involvement than was required in FP7 can be considered.

4. The concentration of research leadership in a relatively small number of organisations, some of which work closely together in the programme, has long-term consequences. We recommend that action be taken to strengthen the capacity of researchers in the EU13 to lead research and we welcome efforts in this direction already in Horizon 2020. This can be achieved by providing support for mentoring early stage researchers in research leadership, by encouraging early stage researchers in the EU13 to team-up with experienced research leaders, by specifying more regional research topics, and by continuing support mechanisms in the EU13.

5. Progress has been made in internationalisation. We recommend that the momentum gained be built on and that further attempts be made to harmonise the research funding policies of Third Countries with the EC and to promote opportunities for leveraging funding in a targeted way.

Implementation

6. We recommend that research 'form should follow function' and the blanket use of particular project approaches with standardisation or near-standardisation of particular requirements be avoided. We observed an increasing degree of non-prescriptiveness as FP7 progressed, particularly in agriculture. We found no evidence that non-prescriptive calls that attract a large number of applicants lead to better research. In agriculture, increasing non-prescriptiveness in the later phase of FP7 was associated with increased competition

between applicants and a decrease in the quality of the funded proposals as indicated by the scores winning proposals were awarded. If there is a clear strategic target, for example the genetic improvement of a keynote species or a known technical challenge, this should be clear in the call. If on the other hand, the purpose of the research is to explore new opportunities, a 'bottom-up' non-prescriptive approach is appropriate. A range of funding modalities can be used to stimulate new speculative lines of enquiry at low cost ('seed-corn funding' and 'horizon-scanning').

7. The approach to supply-chain development research needs revision. It has been too simplistic tending to support the diverse range of activities along a supply chain within individual projects. Projects which have a core strategic target, such as the genetic improvement of keynote species, should not be extended to cover related supply chain questions such as development in the related food sector. The holistic supply chain approach is better supported with groups of projects through strategic programming, with each project better targeting components of supply chains to give a more holistic approach at the programme level. In doing so, choices need to be made based on economic analysis of where Europe can compete and what is required to compete. This can guide the engagement of the private sector, including large enterprises.

8. We recommend that call topic texts be tested for clarity and focus from the viewpoint of potential applicants. This includes stronger signalling of the special features of some requirements such as projects focused on development and demonstration, and scoping projects in work programmes.

Impact

9. Thorough revision of reporting is recommended. The current reporting process is complex, bureaucratic and yet fails to record the output of research in the public domain. It mixes resource auditing in contract management with the reporting of results to the public. There is considerable scope for rationalisation with greater emphasis on publication, i.e. more reporting of outputs rather than inputs. Modern publishing on the internet can be used to enable easy access to reports of project activities and achievements, systematically providing referenced access to the whole portfolio. This would enhance the profile of the programme. The EC's recent support of open access publishing is very welcome and should continue.

10. We recommend that the EC develops comprehensive methodology to evaluate the impact of EU research as part of the reporting system. This needs to extend several years after the completion of the research to capture post-project outputs and impact. Self-reporting and assessment could be effective. The project final report could include a clear self-assessment of a wide range of impacts, including those on policy with a report on how impact pathways are being used. To complement this, there are now methods emerging to monitor scientific impact more effectively (e.g. Current Research Information Systems, euroCRIS).

11. Simple bibliometric analysis was used for the analysis in this report. This tool can, in the hands of experts, become a sophisticated mechanism to not only measure the number of publications and their values but also identify areas of expertise and excellence in Europe and in the collaboration between institutions and countries. Options should be considered to build a team to better use this tool in the future.

12. The projects we examined all had project websites and a wide range of other communication activities, all done in a be-spoke way. The EC's emphasis on the need for each consortium to communicate about its project is understandable but the result is

fragmented and often transient. We recommend that central systems be established to provide these common project communication materials in a standardised and more permanent way. There is considerable scope for using modern information technology to integrate reporting reducing the need for project-based be-spoke approaches.

Annex 1.

Terms of Reference for a group of experts working on the ex-post evaluation of the Seventh Framework Programme, Co-operation Theme 2:

Food, Agriculture, Fisheries and Biotechnology

– INTRODUCTION AND OVERALL OBJECTIVE

These are the Terms of Reference for a group of experts set up by Directorate F of DG Research and Innovation of the European Commission for the ex-post evaluation of the Seventh Framework Programme (FP7) of the European Community for research, technological development and demonstration activities (2007-2013), concerning the Specific Programme "Cooperation" and most notably in the areas of Food, Agriculture, Fisheries and Biotechnology (FAFB).

The overall objective of the exercise is to provide an ex-post evaluation of FP7 rationale, implementation and achievements in the above mentioned areas according to the criteria set out in section 2.2.

Via a combination of **collective and individual work** punctuated by two general meetings and a further one restricted to the rapporteurs to discuss the first draft report, the group of experts will analyse existing evidence including notably the FP7 Progress Report, the annual FP7 Monitoring reports, evaluation and monitoring studies on FP7, ad hoc analyses, including project reports, statistical information and relevant policy documents and reviews.

The rapporteurs will prepare a **final report** providing a detailed analysis and conclusions.

The group of experts will be assisted by a **European Commission Steering Group**.

– MANDATE, DELIVERABLES AND TIMETABLE

o Context and Rationale

The EC Seventh Framework Programme Decision[56] provides in article 7(3) that: "*Two years following the completion of this Framework Programme, the Commission shall carry out an external evaluation by independent experts of its rationale, implementation and achievements.*" This ex-post evaluation should be completed by December 2015.

The present paper relates to the contribution to the ex-post evaluation of FP7 concerning the Specific Programme "Cooperation" and most notably in the areas of Food, Agriculture, Fisheries and Biotechnology. This contribution should be completed by December 2014.

Specific inter-institutional and Commission requirements further frame this evaluation; in particular those related to the Financial Regulation[57] and evaluation standards[58].

This ex post evaluation covers the years 2007-2013, a period during which the European research landscape changed significantly.

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[56] OJ L 412 of 30 December 2006, p1.

[57] Regulation (EU, Euratom) no 966/2012 of the European Parliament and of the Council of 25/10/2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L298 of 26/10/2012) .

[58] SEC (2007) 213 – of 21 Feb 2007.

The size of the EU Budget allocation to FP7 research activities is growing substantially both in real terms and as a proportion of the overall Budget.

New initiatives to stimulate the European Research Area have been launched and a range of new activities and implementation schemes were introduced in FP7 (e.g. mandatory participation of SMEs in specific topics of the calls).

In parallel, greater emphasis has been put on innovation as a cross cutting way of equipping all sectors of our economy to be more competitive.

In times of financial and economic crisis, research efforts are expected to meet major social, environmental and economic challenges, e.g. job creation, food security, bio-resource efficiency, mitigating and adapting to climate change, etc.

More than 500 projects were launched during the course of FP7 under 22 FAFB related calls for proposals (including KBBE, OCEAN, JPROG, AFRICA, ERA-NET, INFLUENZA, AD-HOC) with 20% of these projects having completed their work by the end of 2013.

- **Aspects to be covered, questions to be addressed**

The approach should take into account the overall strategic context for Community actions and in particular the strategies "Innovating for Sustainable Growth: a Bioeconomy for Europe", EU 2020 and Innovation Union.

The FP7 ex post evaluation shall find its roots in previous evaluations and assess the follow-up and implementation of their recommendations.

On this basis, the evaluation should cover the 3 main evaluation aspects:

1. Rationale: entails an analysis of the logic of intervention (i.e. the expenditure programme), the relevance of its objectives and whether the objectives are consistent with the strategic context and to the identified challenges.

2. Implementation: looks at the effectiveness and efficiency of the intervention.

3. Achievements and impacts: focuses on the concrete outcomes and impacts of the intervention. It represents the core of an evidence-based analysis of funded projects that should lead to a reasoned assessment of the added value of the intervention. In the evaluation of EU research projects, the following impacts should be assessed:

- Scientific impacts
- Technological impacts and impacts on innovation
- Economic, environmental and social impacts
- Structural impacts on the European Research Area
- Impact on EU policies
- European added value

Besides the general underlying question on how far has FP7 achieved the objective of the Specific Programme "Cooperation" in the areas of FAFB, the evaluation should indicatively address the specific questions listed hereafter. These are meant to present a non-exhaustive trace for the analysis to be performed.

2.1.1. Evaluation aspect 1: Rationale

- How did the FP7 areas of FAFB contribute to the EU 2020 strategy goals? To which priorities, targets and flagship initiatives did they contribute to?
- Have the work programmes addressed the main societal, environmental and economic challenges on food, agriculture, fisheries and biotechnologies?
- Were the activities and allocated budget within the areas sufficiently and optimally distributed to strengthen the scientific and technological base of the European knowledge based bio-economy (KBBE) and to encourage its international competitiveness?
- What have been the objectives and coverage of topics published within each activity through the Framework Programme period 2007-2013? Have they been sufficiently and optimally distributed?
- How have the objectives and coverage of topics evolved through time to be aligned with the overall EU policy context?
- Has the programme evolved in terms of including less prescriptive topics to allow bottom up approaches to deliver innovative ideas?
- What is the ratio of fundamental/basic versus applied research?
- Strategic research requires systems approaches to avoid trade-offs. How was the disciplinary, inter-disciplinary and trans–disciplinary research present in the calls?
- Any other relevant questions proposed by the group of experts

2.1.2. Evaluation aspect 2: Implementation

- Have calls for funding been developed and processed effectively by the Commission? Has the Commission made a good promotion of FP7?
- Have the undertaken simplification measures been recognised and appreciated by participants?
- Was there a robust competition for funding? Which has been the quality of the proposals? Has the principle of excellence been achieved in project selection?
- Does the programme support dissemination of research results and technology and knowledge transfer activities? Was there a good dissemination of knowledge?
- What was the quality of the reporting?
- Any other relevant questions proposed by the group of experts

2.1.3. Evaluation aspect 3: Impact

- How many projects led to publications in peer reviewed journals? Did they have an impact on the knowledge triangle (connections made between research, innovation and education)?
- Which kind of organisations participated to the actions? Have the actions attracted some of the best research organisations and innovation firms in Europe? Has the SMEs involvement been satisfactory?
- What was the geographical repartition of successful applicants and teams? Which kind of organisations were the coordinators of the projects? What was the geographical distribution? Is it possible to identify patterns?
- Was there a good cooperation between different types of participants? Is the bridge between research and innovation tackled?
- Have project outputs increased the body of knowledge and how? Have they achieved all or most of their objectives?

- Has the inclusion of the innovation dimension promoted the translation of research and innovation into market applications?
- Was there a good exploitation of results? Have projects generated patent applications or other types of intellectual property rights?
- Has this led to any commercial exploitation of results?
- Was he intellectual property rights (IPR) management within the projects suitable to help to safeguard future commercial applications?
- How has this theme impacted the European Research Area?
- Have projects outputs lead to innovation? In which fields and which clients/segments of society can mostly benefit of it?
- Has the programme reinforced the research and innovative capacity of industry? Was the share of EU financial contribution to Industry and SME sufficient?
- Has the programme supported the demonstration of the market potential of new products or processes?
- Has this theme supported policy making, standardisation and legislation?
- Has the programme had a positive leverage effect in promoting national research efforts?
- Any other relevant questions proposed by the group of experts

- **Deliverables and Timetable**

The group of experts is requested to address to the Commission a report, of maximum 100 pages plus Annexes, which includes an analysis of findings, a set of conclusions on the basis of evidence and policy recommendations for the new research programmes.

The main section of the report should be prefaced by a largely self-contained executive summary, not exceeding 5 pages.

All criteria and questions mentioned under point 2.2 should be addressed in a clear text in conformity to the quality criteria defined by the Steering Group of the Commission.

Interim versions of the report will be regular discussed between the rapporteur and the member of the European Commission Steering Group responsible for the panel in question.

The report is to be made publicly available by Commission Services on http://ec.europa.eu/research/evaluations

The group of experts starts its work in early 2014 and its final report should be addressed to the Commission by July 2014 at the latest.

- **Meetings**

It is planned that the group of experts as a whole will meet twice in Brussels. A kick off meeting will take place on 4-5 February 2014 when details on the present Terms of Reference, including the methodology, the sources for the analyses, the deliverables and the timetables will be provided and discussed. The second meeting will take place on 22-23 May to discuss first conclusions of the remote analysis and individual contributions to rapporteurs. Experts will work in remote for the analysis of the documentation and will provide their contribution to the rapporteurs. A further meeting reserved to the rapporteurs will take place in June (24 June to be confirmed) to discuss the first draft of the report. Video/Telephone conferences might be organised when needed.

The rapporteur should be in regular contact with the member of the EC Steering Committee responsible for the panel in question.

The Commission services may, at the request of the group of experts, convene ad hoc expert meetings on emerging issues.

- **OPERATION OF THE GROUP OF EXPERTS**

o **Number, identification and selection of experts**

The group of experts will comprise up to 20 independent experts. It will include the relevant expertise to ensure informed analysis on all of the areas covered by the Theme 2 Food, Agriculture, Fisheries and Biotechnology of FP7 and will also include acknowledged experts in programme evaluation and management.

The independent experts will be appointed on the basis of the following criteria:

- high level of expertise in the fields of research and technological development in particular, as attested by higher education qualifications of at least doctoral level and/or proven by having won prizes and awards at national, European and international level and/or as evidenced by professional experience and skills which are widely recognised;
- appropriate range of skills in the different fields covered by the Theme 2 Food, Agriculture, Fisheries and Biotechnology of FP7, combined with the ability to examine science policy questions and analyse the general context (legislative, political, etc.) into which they fall;
- appropriate language skills.

Provided that the above three conditions are satisfied, other criteria are also taken into consideration:

- appropriate balance between academic and industry expertise;
- ability to assess the societal dimension and strategic relevance of the framework programme and specific programmes;
- a fair balance between men and women;
- a reasonable balance of geographical origins;
- rotation of experts appointed by the Commission services.

Experts are identified from a list, continually updated by an open-ended call for applications (OJ C342 of 22 November 2013) for the constitution of groups of experts assisting the Commission's services for tasks in connection with the Seventh Framework Programme.

o **Working methods**

The experts will meet in plenary to discuss the general set up and running of the evaluation. The plenary will be chaired by an EC official.

The experts will be regrouped in 5 panels, with up to 4 experts each: one for each of the areas of Theme 2 (Food, Agriculture and Forestry, Fisheries and Aquaculture, Biotechnology), plus one panel that will address horizontal issues (International cooperation, ERA, SMEs, Gender, Innovation, Impact on policies) and overall statistical analyses.

Each one of the five panels will have a panel chair and a panel rapporteur who will be appointed by the Commission services during the kick-off meeting (these two functions might be cumulative). The division of work between experts and the organisation of each panel will also be discussed during this meeting. Each panel will be assisted by a representative of the European Commission Steering Group.

The panel rapporteurs will be in charge to prepare a panel report in which they will highlight and exploit main points of individual contributions to their panel.

In addition, the rapporteurs will coordinate with the other panel rapporteurs to prepare (compiling and editing) the overall report, which will be based on the panel reports.

Both reports should be written in conformity with the quality criteria defined by the Steering Group of the Commission and on the basis of all members' written contributions and of relevant material and events identified by the group of experts' members and/or by the Commission.

The Commission staff responsible for the group of experts will be in regular contact with these last one and notably with the rapporteurs to ensure the smooth running of the exercise, and they will attend the meetings to provide appropriate information and orientations. Commission staff will also ensure regular reporting on the progress of the evaluation to members of the Interservice RTD Evaluation Network to assure consistency with the wider PF7 ex post evaluation. The evaluation will be designed and carried out in line with the relevant Commission standards for evaluation and subject to the quality assessment criteria.

The Commission staff responsible for the group of experts will also provide input to the production of the report, notably through the collection of factual evidence.

- **Expert support and evidence-base**

The group of experts will carry out its activities through an independent, robust, evidence-based process. This information base is to be made available to the experts by the Commission services.

Analyses will be conducted on the basis of both quantitative and qualitative data, covering the entire activities in the above mentioned areas. Detailed analyses will also be performed on samples of projects.

The Commission will provide the group of experts with all necessary information, in particular but not exhaustively listing:

- Information on funded projects;
- The FP7 Progress Report
- Annual FP7 Monitoring Reports
- Report from the ex-post evaluation of the Sixth Framework Programmes (FP6);
- Report form the Interim Evaluation of the Seventh Framework Programme;
- Report on Impacts of EU Framework programmes (2000-2010) and prospects for Research and Innovation in Food, Agriculture, Fisheries and Biotechnologies;
- Relevant policy documents and reviews, including the Framework Programmes, the spring reports to the European Council, annual reports on research activities, S/T indicators, benchmarking and mapping data;
- Targeted evaluations and studies carried out by Framework Programme thematic activities;
- Reports from any other evaluation studies and ad hoc analyses relevant to the fields of analysis of the experts;
- Statistical information on the implementation of the activities.

Experts will be expected to be proactive in suggesting and using additional documentation wherever they consider it helpful.

The group of experts is invited to establish contacts with national experts and with national contact points for the exchange of information and discussion, and with representative bodies across Europe and international stakeholder groups.

- **Confidentiality and Credits**

The European Commission and the experts shall treat with confidentiality any information and documents, in any form, disclosed in writing or orally in relation to the ex-post evaluation and identified as confidential.

The experts shall:

(a) not use confidential information and documents for any purpose other than fulfilling its obligations under the contract without prior written agreement of the contracting authority;

(b) ensure the protection of such confidential information and documents with the same level of protection it uses to protect its own confidential information, but in no case any less than reasonable care;

(c) not disclose directly or indirectly confidential information and documents to third parties without prior written agreement of the contracting authority.

(d) return, erase or destroy all confidential documents or files upon completing the review, unless otherwise instructed.

The confidentiality obligation set out in the Appointment Letter shall be binding on the European Commission and the experts during the performance of the task and for five years starting from the date of the payment of the balance unless:

(a) the disclosing party agrees to release the other party from the confidentiality obligation earlier;

(b) the confidential information becomes public through other means than in breach of the confidentiality obligation, through disclosure by the party bound by that obligation;

(c) the disclosure of the confidential information is required by law.

The ownership of the results shall be fully and irrevocably acquired by the European Commission under the Appointment Letter including any rights in any of the results listed in it, including copyright and other intellectual or industrial property rights, and all technological solutions and information contained therein, produced in performance of the Appointment Letter. The contracting authority may exploit them. All the rights shall be acquired by the Union from the moment the results are delivered by the experts and accepted by the European Commission. Such delivery and acceptance are deemed to constitute an effective assignment of rights from the experts to the Union.

The acquisition of ownership of rights by the Union under the Appointment Letter covers all territories worldwide.

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«Food, Agriculture and Fisheries, and Biotechnology» was one of the 10 Themes within the specific «Cooperation» programme of the European Union's Research and Innovation funding programme for the period 2007-2013. This report has been produced by a group of independent experts in charge to assess the rationale, implementation, achievements and impacts of this theme.

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