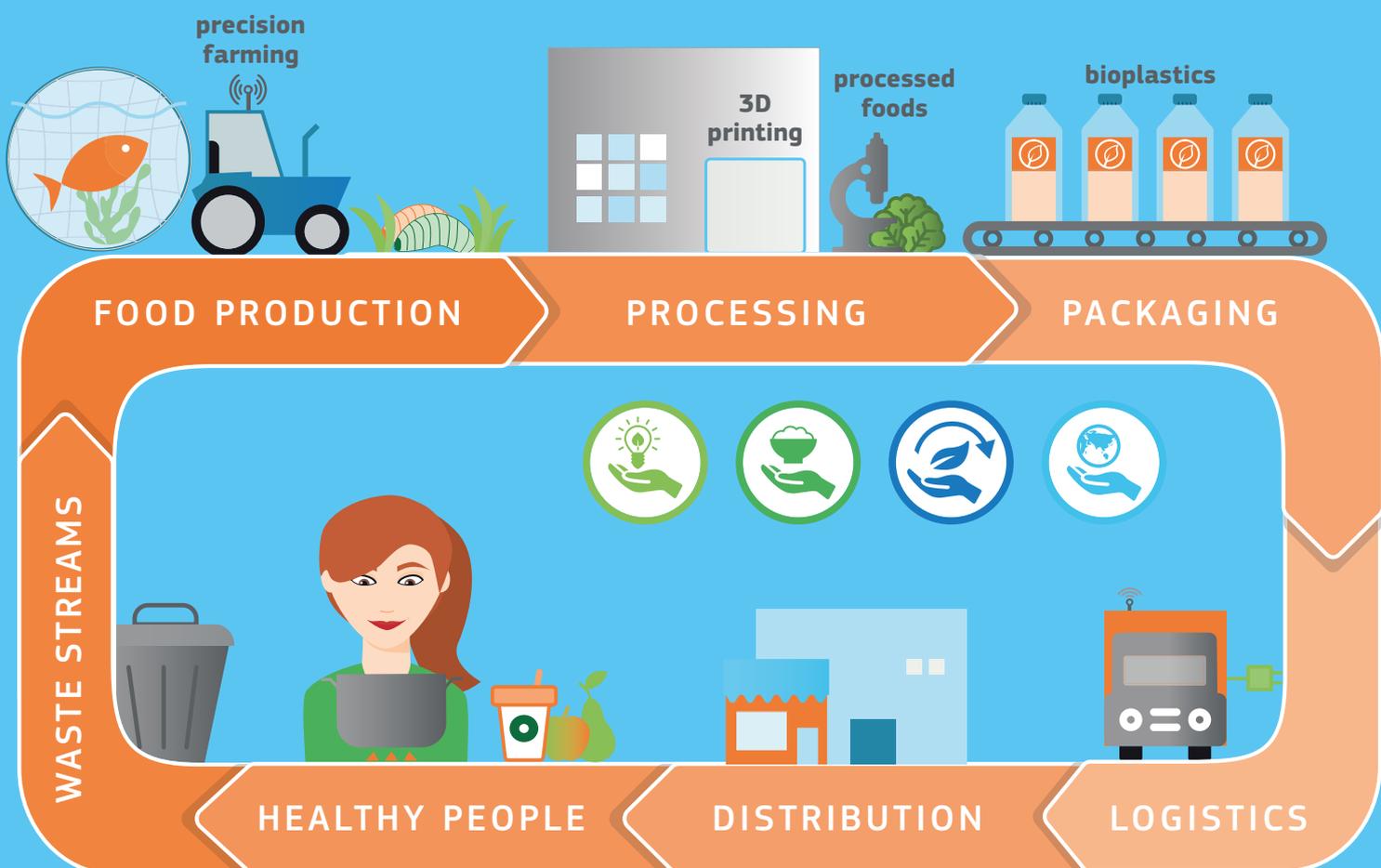




research^{eu}

RESULTS PACK ON FOOD SYSTEMS TRANSFORMATION

FOOD 2030: Innovative EU research ensures food system is future-ready



Europe's food production and consumption will play a pivotal role in ensuring food and nutrition security (FNS) in the face of the combined impacts of, climate change, resource scarcity, land degradation, biodiversity decline, under- and over-nutrition, population growth and geopolitical instability. Safeguarding food and nutrition security in the long term will require the systemic transformation and future-proofing of our current-day food systems, which at present are mainly linear, fragmented and unsustainable.

The European Commission aims to tackle the FNS challenge with research and innovation (R&I) policies designed to future-proof our food systems so that they can become more sustainable, resilient, responsible, inclusive, diverse and competitive.

This systemic approach to connect, scale-up and boost EU Food R&I is referred to as FOOD 2030 and will provide solutions to four overarching food system priorities. These are NUTRITION for sustainable and healthy diets; CLIMATE resilience and environmental sustainability; CIRCULARITY and resource efficiency; and finally, INNOVATION and the empowerment of communities.

Groundbreaking EU research in the spotlight

This CORDIS Results Pack focuses on new approaches the four FOOD 2030 priorities by showcasing 13 ambitious cutting-edge EU research projects funded under the EU's FP7 and Horizon 2020 research programmes relevant to food system transformation.

***Flourish** developed ground and aerial robots to increase agricultural yield, reduce pesticide use and mitigate food security, thus improving sustainability, while **INFARM** contributed to sustainable agriculture by improving the environmental footprint of plants. **RECARE** developed measures to combat climate change related soil degradation. **HEALTHYMINORCEREALS** contributes to climate resilience by investigating minor cereal varieties for biotic and abiotic stress resistance. **FOODINTEGRITY** encourages food transparency to minimise food fraud and ensure a responsible food supply chain. **PROHEALTH** also promotes responsibility by reducing diseases in pig and poultry, and **DEPURGAN** provides eco-friendly manure management. Finally, **EARLYNUTRITION** explores how early nutrition programming and lifestyle factors impact the rates of obesity and related disorders.*

*A range of technologies, approaches and business models are reflected in **FoodSMART**, which created a new mobile app to help consumers -make healthier food choices, while **NUDGE-IT** combats obesity by analysing what determines our food choices. **SUCCESS** examines processing and production in the seafood industry and proposes ways to enhance competitiveness and sustainability. **ARBUATEM** raises awareness of the dangers of using waste water for urban agriculture in low and middle-income countries. Finally, **MareFrame** engages stakeholders in developing tools to sustain healthy marine ecosystems and fisheries.*

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Early nutrition determines later health

The increase in overweight children constitutes a major health concern for future diseases such as obesity and diabetes. Therefore, it is of paramount importance to translate scientific knowledge into dietary recommendations that are implemented early on in life.

Accumulating evidence indicates that early nutrition and lifestyle have long-term effects on later health. Food choices during pregnancy and eating patterns in infancy can affect a range of different bodily functions. These programmed changes in the body increase the likelihood of becoming overweight and developing consequent metabolic disorders which manifest later in life. Although metabolic programming for obesity is multifactorial, maternal obesity and excessive pregnancy weight gain emerge as independent risk factors of obesity in childhood.

The EU-funded EARLYNUTRITION (Long-term effects of early nutrition on later health) project was a large collaborative effort among researchers from 35 institutions in 12 European countries, the United States and Australia who joined forces to fill the gap between scientific advances and their practical implementation into recommendations for everyday life. “The key objective was to investigate how early nutrition programming and lifestyle factors impact the rates of obesity and related disorders,” explains project coordinator Prof. Berthold Koletzko. In particular, the project focused on the mechanisms of metabolic programming and how their manipulation could lead to better health later in life.

Association of obesity with early life nutrition

EARLYNUTRITION explored different key hypotheses on likely causes and pathways of early life origins of obesity. These included the *in utero* hypothesis that suggests that intra-uterine exposure to glucose causes permanent changes to the foetus. Maternal obesity was found to alter placental lipid metabolism while dietary intervention studies in obese pregnant rodents showed proof of principle that interventions can reduce obesity and related disorders. In addition, researchers obtained metabolome profiles of pregnant women that allowed them to identify specific obesity-related targets with therapeutic value.

The second hypothesis tested during EARLYNUTRITION – the accelerated postnatal weight gain hypothesis – proposed an

association between rapid weight gain in infancy with a higher obesity rate later in life. Researchers performed prospective analyses of 39 mother-offspring cohorts for gestational weight gain, body composition and smoking in relation to offspring adiposity. They detected no correlation between the intake of beneficial omega-3 fatty acids during pregnancy and adolescent adiposity or early type-2 diabetes. Interestingly, following nutritional analysis of breast milk composition they observed an association between pre-pregnancy weight and milk insulin levels.



“The key objective was to investigate how early nutrition programming and lifestyle factors impact the rates of obesity and related disorders”

The effect of early life dietary interventions

In another part of the project, randomised trials in pregnant women and infants as well as follow-up studies in childhood were performed to test the mismatch hypothesis. According to this hypothesis, a sub-optimal perinatal and an obesogenic childhood environment increase the predisposition to obesity and corresponding co-morbidities.

Investigation of a number of pre- and post-natal interventions indicated that reduced protein intake during infancy leads to a significant reduction in obesity risk. “Along with promotion of breastfeeding, this is the most powerful strategy for prevention of childhood obesity known today, and it was

promptly implemented in respective EU guidelines,” outlines Prof. Koletzko.

prevention strategies for tackling the childhood obesity epidemic.

Considering that obesity forms the basis for the development of diabetes, high blood pressure and heart disease, prevention during the early stages of life has the potential to achieve far greater benefits than interventions at later stages. EARLYNUTRITION findings considerably improve our understanding of the impact of early nutritional programming on health during childhood, adolescence and adulthood. Collectively, project results expand existing dietary recommendation guidelines and identify novel

Project	EARLYNUTRITION - Long-term effects of early nutrition on later health
Coordinated by	Ludwig Maximilian University of Munich in Germany
Funded under	FP7-KBBE
Project website	http://www.project-earlynutrition.eu



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New mobile app for healthier food choices when dining out



Consumers can now make better informed decisions about what they are eating thanks to a new smartphone app designed by EU-funded researchers. This new mobile nutrition guide paves the way for better, smarter and more personalised nutritional choices to improve health and well-being.

Over the last few years, the frequency of dining at restaurants or other out-of-home dining establishments in Europe has radically increased. Yet, compared to meals prepared at home, restaurant fare tends to contain more calories, total fat, saturated fat and sodium. Eating out is often cited as the primary reason for an unhealthy lifestyle and increased obesity levels as consumers have very little knowledge regarding the nutrient profile of the food.

owners. “It could be easily argued that it is a fundamental right for people to know what they are eating,” says project coordinator Professor Heather Hartwell.

FoodSMART’s new mobile application is designed to provide food service providers and consumers with a range of food-related information. For example, it informs consumers about the nutritional value, presence of possible allergens, food provenance and carbon footprint of each meal.

The newly developed app is a helpful tool for users wishing to consume foods which align with their particular dietary preferences and restrictions. “Just by using GPS location, the app identifies the nearest canteen or restaurant and then takes users through a range of options that they can personalise and adjust to suit their own diet. A menu of available dishes is then displayed, and by clicking on them, consumers can find out additional information like nutritional content and the origin of ingredients,” further explains Prof. Hartwell.

What’s more, the app offers the possibility of printing Quick Response (QR) codes on menus so that consumers can scan them with their phones to access the menu and all the additional information.

Reducing obesity levels

Any initiative encouraging consumers to eat more ‘attentively’ could help reduce calorie intake. In Western Europe, obesity has risen by 15% over the last 10 years, and this has been associated with dining out on a frequent basis. “Research has shown that a third of British consumers underestimate how many calories they are eating each day. Public health officials in the UK are now recommending food



“It could be easily argued that it is a fundamental right for people to know what they are eating”

Technology can greatly help consumers make smart nutritional choices based on their personal preferences. Therefore, a pan-European partnership between industry and academia developed the FoodSMART (Shaping Smarter Consumer Behaviour and Food Choice) project. The project has created an app that makes it easier for consumers to access more information about their food, thereby responding to the increasing demand for full transparency on the ingredients and health implications of the food served outside home. FoodSMART is a four-year project with researchers from Austria, Denmark, France, Greece and the UK.

Choosing the right food

New EU regulations require the clear labelling of allergen presence for food served by hotels, restaurants and catering



operators and manufacturers reduce portion size and cut calories in their products by 20% by 2024," says Prof. Hartwell.

All this data shows the need to make a radical change on the level of information provided about the food served outside the

home. As part of its mission to reduce obesity levels, this innovative project should empower people to make informed food choices, helping them overcome challenges like a lack of clear labelling on dishes and improper calculation of the nutritional content on menu items.

FoodSMART constitutes a ground-breaking effort to provide diners with enhanced meal information when eating out. The project has just completed the phase of testing its app and is now in the process of making it available on the market. Reports indicate that this mobile app can give a competitive advantage because it considers workers' health, provides accurate data on the dish consumed and does not include advertisements.

Project	FoodSMART - Shaping Smarter Consumer Behaviour and Food Choice
Coordinated by	Bournemouth University in the United Kingdom
Funded under	H2020-MSCA-RISE
Project website	https://microsites.bournemouth.ac.uk/foodsmart
Project video	https://bit.ly/2rPKGdt

Europe turns to the production of minor cereals



Cereals differ widely in the concentration and composition of their nutritional compounds and antioxidants. Therefore, there is growing interest in enhancing the production of cereal varieties for diversification in nutrition.

The major cereals wheat, barley and maize account for more than 85% of the cereals currently grown and produced on a global scale. However, they are dependent on large inputs of artificial fertilisers, pesticides and energy, and are also more vulnerable to environmental pressures such as drought and crop diseases.

Rye, oat and hulled wheat species (spelt, emmer and einkorn) are grown on a much smaller scale and are classified as minor cereals. Despite their lower yields, interest in cultivating them

is increasing as they are better suited for organic farming, need lower inputs of fertilisers and pesticides, and have more resilience.

The EU-funded HEALTHYMINORCEREALS (An integrated approach to diversify the genetic base, improve stress resistance, agronomic management and nutritional/processing quality of minor cereal crops for human nutrition in Europe) project was designed to enhance the cultivation and production of minor cereals. The rationale was that healthy nutrition



requires food diversification for maximum uptake of bioactive compounds and micronutrients. Furthermore, “minor cereals have a great potential in sustainable agriculture where production is simultaneously environmentally friendly,” adds project coordinator Dr Dagmar Janovska.

“Minor cereals have a great potential in sustainable agriculture where production is simultaneously environmentally friendly”

New minor cereal varieties with improved characteristics

HEALTHYMINORCEREALS applied state of the art methods for the genetic characterisation and phenotyping of more than 800 genotypes of five minor cereal species, namely spelt, rye, oat, einkorn and emmer. Many minor cereal varieties and their wild relatives have fallen out of use but have been conserved in European gene banks for years. “The objective was to identify promising genetic characteristics for yield, resistance to important fungal diseases, more efficient use of fertilisers, nutritional quality, suitability for food processing and other beneficial traits,” explains Dr Janovska.

Cereals are known to be rich in antioxidant compounds which remove highly toxic free radicals and thereby minimise oxidative stress and inflammatory diseases. Researchers analysed minor cereal species for phenolic compounds, β-glucan and dietary fibre content. Interestingly, they discovered that certain minor cereal species contain much higher levels of total antioxidants in comparison to currently cultivated varieties of common wheat.

In addition, minor cereals are more robust and resilient and therefore better able to withstand adverse climatic conditions and resist certain crop diseases. Considerable effort was put into optimising conditions for cultivation in four European countries with different climates and soils, with an emphasis on organic fertilisation. HEALTHYMINORCEREALS partners identified varieties that grow better on marginal soils and are suitable for sustainable agriculture.

Minor-cereal-based foods

In the final stage of the project, the consortium organised farmer-participatory trials using the most promising agronomic management practices, which were further investigated in commercial fields rather than agricultural stations. In addition, they studied milling, extrusion and baking processes for minor cereals while maintaining the nutritional value of the crops. Food safety and quality were a top priority of the project, considering protocols that could be scaled up for industrial purposes.

By taking into account European regional differences, partners are considering various approaches for introducing minor cereals onto the market. Dr Janovska is confident that “HEALTHYMINORCEREALS will have a major impact on the cultivation and consumption of minor cereals in Europe, responding at the same time to global environmental changes, as well as consumers’ increasing demands for healthy food.”

Project	HEALTHYMINORCEREALS - An integrated approach to diversify the genetic base, improve stress resistance, agronomic management and nutritional/processing quality of minor cereal crops for human nutrition in Europe
Coordinated by	Crop Research Institute in the Czech Republic
Funded under	FP7-KBBE
Project website	http://healthyminorcereals.eu



The neurobiology behind food choice: what makes us eat too much?



The alarming increase in obesity levels worldwide constitutes a serious health issue with significant socioeconomic impacts. To foster healthier lifestyles, it is necessary to understand the factors that influence eating choices.

Despite health information, education and taxes on harmful foods, the rates of obesity and non-communicable diseases remain high. As a result, governments worldwide are looking to improve citizens' health by nudge interventions, small yet relevant behavioural stimuli that aim to change what people choose to eat.

NUDGE-IT worked to translate insights from basic research into policy recommendations, bridging the gap in understanding between mechanistic insight and translational studies in humans. In this context, scientists integrated behavioural and observational studies with neurobiological data studies to educate stakeholders on dietary recommendation policies.



“The overall aim of NUDGE-IT was to better understand decision-making in food choice and to build predictive models to contribute to improving public health policy”

However, to generate effective recommendations, it is central to comprehend the determinants of dietary choices. Towards this goal, the EU-funded NUDGE-IT (The Neurobiology of Decision-Making in Eating – Innovative Tools) project brought together leading European experts in the field to determine effective strategies for adhering to nutritional guidelines. “The overall aim of NUDGE-IT was to better understand decision-making in food choice and to build predictive models to contribute to improving public health policy,” explains project coordinator Prof. Gareth Leng.

Food choices are influenced by cultural and social pressures, cognitive factors as well as familial, genetic and epigenetic factors. In addition, food marketing and labelling, economic factors and the perception of healthy eating play a role in dietary habits. “Some factors are likely to be barriers to the efficacy of certain types of policy intervention or raise concerns about negative consequences for some sectors of society,” outlines Prof. Lang.

Determinants of food choices

The project made a number of interesting observations including the powerful influence of homeostatic and hedonic or reward brain mechanisms on food consumption and body weight. Interestingly, scientists discovered that both fat mass and bone influence overall food intake, while signals from the gut and fat mass seem to additionally affect the reward pathways. This may have potential implications in efforts to reduce the bone-to-mass index across the population. Furthermore, deficiency of a specific nutrient may drive an increase in food intake to counterbalance the loss, forcing an inevitable increase in energy intake.

Although body weight is considered to be 80% heritable, emerging evidence indicates that stress and impaired nutrition during gestation and in early post-natal life seem to have lifelong repercussions on physiology and metabolism. Undoubtedly, the metabolic status of the mother during gestation influences the brain dynamics of the foetus while overnutrition in early life not only produces weight gain, it also induces a lifelong change in food choice. Nonetheless, NUDGE-IT data suggest that interventions in children's diet to promote healthy eating can be very effective. This probably reflects their rapid growth rate and suggests a dynamically regulated homeostatic pathway.

The neurobiology of eating habits

Undoubtedly, when it comes to food, decision-making is tightly linked to activity in certain brain regions. Alterations in these areas may be associated with the behavioural changes that lead to obesity.



Based on this, NUDGE-IT employed neuroimaging modalities to study the neural correlates and processes implicated in the behaviour towards food. Researchers identified the neural circuits involved in food valuation and selection, further identifying brain sub-regions that control appetite. Interestingly, they discovered a novel association between individuals' physiological and psychological status and food choice.

A more holistic view of food choice mechanisms was made possible by mathematical modelling, building a framework towards evidence-based dietary policies. "We must continue to combine mechanistic and translational studies and tackle compliance issues by tailoring nudging policies to specific populations," concludes Prof. Leng.

Project	NUDGE-IT - The Neurobiology of Decision-Making in Eating – Innovative Tools
Coordinated by	University of Edinburgh in the United Kingdom
Funded under	FP7-KBBE
Project website	https://www.nudge-it.eu/

New robots set to transform farming



EU-funded scientists developed adaptable ground and aerial robots that can increase agricultural yield, reduce pesticide use and mitigate food security risks that are closely intertwined with agricultural uncertainty.

European consumers expect a clean supply chain and biodiversity to be conserved. Therefore, reducing the inputs of pesticides and chemical fertilisers to a minimum and/or replacing them by agro-ecological or robot solutions is required. Furthermore, the average age of European farmers is among the highest of all sectors, thus farming needs to attract young people with attractive working opportunities.

This is where the new agricultural robot solution for precision farming developed within the context of the EU-funded Flourish (Aerial Data Collection and Analysis, and Automated Ground Intervention for Precision Farming) project can play a part. Use of robots in precision farming has the potential not only to increase yield, but also to reduce the reliance on fertilisers, herbicides and pesticides through selectively spraying individual plants or through weed removal.



Helping farmland flourish

Precision farming combines technologies that customise the care that plants receive without increasing labour on the farmer's side. The project consortium targeted the development of innovative agriculture techniques by monitoring key indicators of crop health and targeting treatment only for plants or infested areas that require it.

"Compared with conventional practices, precision farming techniques are much friendlier to the environment and bring more economic benefits," say project coordinator Prof. Roland Siegwart and researcher Dr Inkyu Sa. Given that most of the pesticides applied are herbicides to control the weeds, radically reducing the use of these chemicals and detecting parts of the crop field that are free of infestation will help to grow healthier crops.

Farming with drones and robots

Development of precision farming techniques is a very active area of research, so the goal of Flourish was to bridge the gap between the current and desired capabilities of agricultural robots. The project consortium developed an autonomous farming system where drones and robots work together to monitor the crop and precisely remove weeds. The newly developed robotic system combines the aerial survey capabilities of a small autonomous multi-copter unmanned aerial vehicle (UAV) with a multi-purpose unmanned ground vehicle (UGV).

"Compared with conventional practices, precision farming techniques are much friendlier to the environment and bring more economic benefits"

"Equipped with a camera, various sensors, GPS and statistical software the UAV can scan different crop characteristics such as height, canopy cover and chlorophyll levels, and provide information related to plant 'phenotyping'," explain Prof. Siegwart and Dr Inkyu Sa. The drone can also distinguish between crops and weeds, while advanced algorithms enable it to optimise its flight path. Once the UAV has completed its task it communicates the areas that need attention to the UGV.

Utilising the data delivered from the UAV, the UGV prototype, called Bonirob, autonomously navigates its environment and performs actions at set locations. For example, it can spray a pesticide onto a selected crop area, and in the case of weed presence, it can get rid of them mechanically, avoiding the use of dangerous herbicides.

Image recognition plays a key role in Bonirob's operation. Based on parameters such as plant colour, shape and size, the robot can help farmers classify plants more easily. Examining crop patterns alongside images, it can also differentiate more accurately between the desired plants and weeds even when their visual appearance changes significantly due to weather conditions or growth.

Currently, Flourish members are working with end users to define product specifications and ensure that interests stay aligned. In addition, they are evaluating and optimising the newly developed system to make it more robust and easy to use with a short setup time. Project members are also trying to facilitate interoperability with other products on the market by utilising standard communication protocols such as the robot operating system. This will ensure minimal barriers to entry when the system is ready to enter the market.

Technological advancements in farming such as those introduced by Flourish will enable farmers to minimise chemical use and produce healthier crops and higher yields. The system is also expected to reduce costs for farmers and minimise the environmental impact of crop farming.



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Project	Flourish - Aerial Data Collection and Analysis, and Automated Ground Intervention for Precision Farming
Coordinated by	ETH Zurich in Switzerland
Funded under	H2020-LEIT-ICT
Project website	http://flourish-project.eu

Decision support framework for more effective fisheries management



Today's fisheries are generally managed using a single-species approach that is inherently flawed. A multi-species or ecosystem-based approach is needed to improve the situation and ensure future sustainability.

An ecosystem-based approach to fisheries management (EAFM) takes a lot more data into account than a single-species approach. It can provide more appropriate guidelines to fisheries managers, helping them utilise resources as sustainably as possible.

Moving away from single-species fisheries management methods

"The ultimate objective of MareFrame was to create the necessary tools and guidelines to facilitate the increased implementation of an EAFM in Europe," says Dr Anna Kristín Daniélsdóttir, coordinator for the EU-funded MareFrame (Co-creating Ecosystem-based Fisheries Management Solutions) project. "Our goal was to contribute to removing the barriers that prevent more widespread use of EAFM."

To achieve its aims, the project team developed a decision support framework (DSF). It consists of a co-creation process, ecosystem models, decision support tools and educational resources.

Tools to sustain healthy marine ecosystems and fisheries

Co-creation is a theory of interactions that combines analytical and participatory tools to generate knowledge that has scientific acceptability (credibility), policy relevance (salience) and social robustness (legitimacy). The findings show that a "co-creation

approach leads to benefits beyond what could be achieved through traditional research and could effectively contribute to the implementation of an ecosystem approach to fisheries management in Europe, especially since stakeholder input and acceptance are key to changes in the marine sector," notes Dr Daniélsdóttir.

Project partners devised and advanced 10 ecosystem models that were then tested in eight case studies. The case studies ranged from data-rich marine ecosystems with a long history of fisheries exploitation, to data-poor systems where biological, ecological, social and economic information was lacking. Dr Daniélsdóttir explains that the models "contain information fisheries managers and decisionmakers need to gain a realistic idea of how their decisions today might impact key variables in the ecosystem tomorrow."

The development of decision support tools enables stakeholders like fisheries managers and decisionmakers to easily interpret the ecosystem models. The tools also allow them to evaluate trade-offs between scenarios across a range of relevant dimensions while taking their preferences and priorities explicitly into account. Most of these DSF tools are generic and can be readily applied to new cases, making them useful beyond the project.

Researchers created educational materials relevant for EAFM and held advanced training schools, workshops and webinars where the resources were used. The materials can be downloaded or used directly via the tutor-web tool. The content is freely available for instructors, and can be assigned as lessons for students. They produced a roadmap in the form of a policy brief for the integration of DSF for EAFM. It includes the identification of barriers for wider DSF implementation and recommendations for EU decisionmakers and policymakers on how to overcome these. Lastly, team members designed an interactive learning tool to train the main DSF users.

Don't let successful EAFM implementation stop here

Dr Daniélsdóttir is hoping to maintain and build on the momentum and enthusiasm created by MareFrame. An upcoming special issue of the Fisheries Research journal will be dedicated to peer-reviewed publications on its outcomes. The project has also been featured



"Applying an ecosystem-based approach will not only help protect the environment and increase sustainability, but also safeguard the costly investments of the fishing industry and increase their value"

in the International Council for the Exploration of the Sea, a global organisation that develops science and advice to support the sustainable use of the oceans, and the General Fisheries Commission for the Mediterranean roadmaps.

“Applying an ecosystem-based approach will not only help protect the environment and increase sustainability, but also safeguard the costly investments of the fishing industry and increase their value,” she adds. “Fisheries are an economic activity with significant social impact.”

Dr Daniëlsdóttir concludes: “EAFM enables us to take such externalities into account in management, in opposition to the traditional single-species approaches that are currently being applied in most fisheries. If successfully implemented, the approach ensures an enhanced and meaningful participatory process, which is particularly relevant due to the complexities of the EAFM and the EU institutional setting.”

Project	MareFrame - Co-creating Ecosystem-based Fisheries Management Solutions
Coordinated by	Matis in Iceland
Funded under	FP7-KBBE
Project website	http://www.mareframe-fp7.org



Preventing and remediating soil degradation in Europe



An EU-funded project has brought together a multidisciplinary team from across Europe to find practical measures to sustain soil health and fertility. From Iceland to Cyprus, researchers provided detailed information on the geographical spread of nine soil threats, how they impact soil functions and ecosystem services and what measures can be implemented to prevent further soil degradation.

Soil degradation is a worrying phenomenon worldwide, and the EU makes no exception. A considerable amount of all Europe’s land surface is already subject to erosion that affects over 100 000 hectares per year, while soil sealing (the permanent covering of soil by buildings and infrastructures) leads to the loss of more than 1 000 km² of productive land each year.

Given that soil formation is an extremely slow process, fertile soils should be adequately monitored, protected and conserved to ensure that food production capacity and other important soil functions are not lost or diminished.

With the importance of soil in mind, the EU-funded RECARE (Preventing and Remediating degradation of soils in Europe through



Land Care) project was launched in November 2013 to develop effective prevention, remediation and restoration measures. Although there is a large body of knowledge available on soil threats in Europe, this knowledge is fragmented and incomplete.

Europe's nine soil threats

Soil degradation is caused by a mixture of biophysical, socio-economic and political factors, all of which vary across Europe. Therefore, a total of 17 case study areas were examined to find appropriate responses by combining global expertise with local knowledge.

Soil experts provided an extensive overview of the threats that impact agricultural productivity and the environment. The defined soil threats are erosion, salinisation, compaction, sealing, desertification, floods and landslides, which result in loss of organic matter and fertility, contamination and a decline in soil biodiversity. "Not only did RECARE define the threats to soil, it also gave descriptions of soil degradation, key indicators, methods to assess the threat, effects on other soil threats, and the effects on soil functions," explains project coordinator Prof. Coen Ritsema.

RECARE also produced a review of potential measures that can be applied to combat these soil threats. For example, in a small mountainous region in Switzerland, where soil erosion by water – either by means of rain splash or by rill and gully erosion – is frequent, researchers have used a device called a Dyker to produce

“RECARE tested and shared a wide array of effective solutions for prevention, remediation and restoration measures in the battle against soil threats”

small dams between ploughing furrows in potato fields. Results clearly show fewer signs of erosion compared to untreated furrows.

The project also examined the risk of post-fire erosion in an arid mountainous region of Portugal, where prolonged dry summers can lead to wildfires. Recent field trials in the Portuguese case study area revealed that mulching with forest logging residues, which are widely available in the region, is extremely effective in reducing erosion in recently burnt areas.

In Norway, erosion caused by flooding and landslides is a major soil threat, as floods cause a remarkable increase in both suspended sediment and nutrient loads. The case study showed that retention dams in forest areas can successfully prevent fast and excessive water discharge in rivers.

Research in Cyprus focused on soil erosion in a steep mountainous terrain; around some small rural mountain communities, large areas have been converted into agricultural terraces. However, due to the decreasing population in these areas and high production costs, many terraces are no longer cultivated and maintained. This can sometimes cause a domino effect of collapsing terrace walls. The Cyprus research team involved a wide variety of stakeholders to rehabilitate dry-stone retention walls that proved effective in preventing soil erosion.

“RECARE tested and shared a wide array of effective solutions for prevention, remediation and restoration measures in the battle against soil threats,” states Prof. Ritsema. The project’s soil management strategies are expected to protect soils and related ecosystem services in different areas across all of Europe over the long term.

Although the initiative is not yet complete, the latest project results can be found at a dedicated RECARE information hub. Research outputs are freely available to scientists and all those working with and advising on soil protection, to the benefit of all.



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Project	RECARE - Preventing and Remediating degradation of soils in Europe through Land Care
Coordinated by	Wageningen University in the Netherlands
Funded under	FP7-ENVIRONMENT
Project website	http://recare-project.eu

Novel strategies to combat production diseases in pigs and poultry



The intensification of farming increases the risk and susceptibility of pigs and chickens getting production diseases. This makes animal husbandry practices less efficient, resulting in huge financial losses.

Production diseases refer to those conditions that are associated with the intensity of the production of a livestock system. They are induced by management procedures. Production diseases harm animal health and welfare, lead to inefficiencies that reduce profitability and product quality, and increase environmental footprint and antibiotic use. Such diseases are estimated to lower the efficiency of pig and poultry systems by 10-15%.

"The evolution of production diseases is clearly challenging existing options to prevent and control them," says Prof. Ilias Kyriazakis, coordinator for the EU-funded PROHEALTH (Sustainable intensive pig and poultry production) project. "There's a need for new tools and innovative solutions." To address this issue, the project is developing effective control strategies to reduce the negative impact of the conditions on animal health and welfare.



"PROHEALTH will enable the production of better quality products in a welfare-friendly manner, while improving the competitiveness and sustainability of modern pig and poultry farming in Europe"

New knowledge to develop effective management and control strategies

Now in its fifth and final year, PROHEALTH has made several key findings. They include determining the biosecurity score and risk factors for production diseases in pig, broiler and layer chicken, and turkey farms across the EU.

Project partners identified the genetic and environmental factors involved in neonatal survival that exert long-term developmental

influences on the health of pigs and poultry. They also characterised novel phenotypic markers of beneficial sow physiological and behavioural traits. These will be applied in genetic selection to improve piglet survival. Research showed that sows from a more enriched gestation environment, and those given improved human-animal interactions, have reduced stress and lower neonatal piglet mortality.

The project team also identified the most common production diseases in broiler breeder production and found that *Escherichia coli* infections were the most common cause of mortality. The foot pad was shown to be a possible port of entry for Gram positive bacteria, resulting in increased mortality and poor health.

In addition, PROHEALTH conceived nutritional strategies for reducing the prevalence of production diseases in pigs and poultry. The strategies accounted for the interaction between nutrition and genotype in such livestock. Good hygiene during housing improved pig health in the growing-finishing phase and pig weight at slaughter. However, these improvements were largely affected by pig genotypes, so not all pigs benefited equally from ideal environments.

By using innovative environmental monitoring sensors, researchers quantified the farm environment's contribution to the expression of respiratory diseases in pigs over time. They developed novel genetic biomarker panels that could potentially diagnose production diseases in pigs and poultry. A genetic signature that can determine pigs with respiratory deficiencies and significant gene expression changes associated with lumbar kyphosis (humpy-back pigs) was also identified.

On the right path to improved health and welfare for pigs and poultry

PROHEALTH is currently synthesising the results and drawing up recommendations on the most viable ways to control production diseases that add value, are societally acceptable and have a true impact on animal health. "The outcomes will help stakeholders make informed choices on how to best control production diseases," notes Prof. Kyriazakis.

During the final six months, the project will produce a series of best practice guidelines and policy briefs based on the results. It will also



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identify economically viable and socially acceptable ways to control pathologies, with an emphasis on animal welfare implications.

“Ultimately, PROHEALTH will enable the production of better quality products in a welfare-friendly manner, while improving the competitiveness and sustainability of modern pig and poultry farming in Europe,” concludes Prof. Kyriazakis.

Project	PROHEALTH – Sustainable intensive pig and poultry production
Coordinated by	University of Newcastle upon Tyne in the United Kingdom
Funded under	FP7-KBBE
Project website	http://www.fp7-prohealth.eu

The dangers of using wastewater for urban agriculture



Researchers with the EU-funded ARBUATEM project are raising awareness about the dangers of using wastewater for urban agriculture in low and middle-income countries.

Nearly 20 million hectares of arable lands around the world are irrigated with wastewaters, giving rise to 10 % of the world population’s food production. Yet despite this significant use, almost nothing is known about the presence, evolution or dissemination of antibiotic resistant bacteria and genes – or their possible transmission to humans and animals via the food chain.

To fill this knowledge gap, researchers with the EU-funded ARBUATEM (Antibiotic resistant bacteria and genes, associated with urban agriculture in Low and Middle Income Countries: Ecological and medical perspectives) project set out to raise awareness about the dangers of using wastewater for urban agriculture in low and middle-income

countries (LMICs). “The goal of the project is to thoroughly investigate the role of the environment and wastewater as a source for the emergence and spread of antimicrobial resistance in two African countries”, says project coordinator Laura Piddock. “By measuring the potential of wastewater used in urban agriculture to disseminate antibacterial resistance in LMICs, we’ll be able to better protect our food chains.”

Understanding the resistance

The project aims to connect agriculture, the environment and health. In LMICs, urban agriculture has been developed by urban farmers



to supply food to the city inhabitants. Due to water scarcity and cost, urban farmers generally use untreated wastewater irrigation.

In three different cities, researchers randomly collected wastewater samples used for urban agriculture from canals near agricultural fields. The three cities were Ouagadougou, Burkina Faso, and Ngaoundere and Yaounde in Cameroon.

“Using state-of-the-art metagenomic DNA sequencing and bioinformatic pipelines, we analysed the presence of bacteria and drug-resistant genes found in the wastewater,” explains Piddock. Along with DNA sequencing, ARBUATEM researchers also used analytical chemistry, molecular biology, metagenomic approaches and computational biology to characterise antibiotic resistant bacterial community structures and antibiotic resistant genes (ARGs) in untreated wastewaters and the corresponding irrigated agricultural sites.

“The new scientific data arising from this project will provide new information on factors that drive resistance,” says Piddock. “We can then work on minimising these factors by developing strategies to prevent further spread of antibiotic resistant bacteria and ARGs worldwide.”

European leadership

Antimicrobial resistance (AMR) is a global threat that knows no borders. They disseminate very rapidly via the food chain, global travel and medical tourism. If not urgently addressed, drug resistance in LMICs will likely become a global issue, putting additional pressure on European healthcare facilities. “This project highlights Europe leadership in AMR research,” says Piddock.

Although the project is ongoing, results have already been produced. “What we have found is that wastewaters harbour a wide diversity

“By measuring the potential of wastewater used in urban agriculture to disseminate antibacterial resistance in LMICs, we’ll be able to better protect our food chains”

of pathogenic bacteria, as well as antibiotic resistant genes,” adds Piddock. “All the factors involved in antibacterial resistance were found in these wastewaters, thus revealing them to be reservoirs for the dissemination of antibiotic resistance.” According to Piddock, the solution is water sanitation and good public health systems.

As the project moves forward, Piddock says that the challenge will be to obtain funding to build on their findings. “It is critical to further investigate the dynamic of antimicrobial resistance in wastewater ecosystems and to further understand to what extent the exposed human and animal populations are affected,” she says.

At the end of the project, Piddock says that all information will fall into the public domain, where it will help scientists and decision makers improve policies for tackling antibacterial resistance.

Project	ARBUATEM – Antibiotic resistant bacteria and genes, associated with urban agriculture in Low and Middle Income Countries: Ecological and medical perspectives
Coordinated by	University of Birmingham in the United Kingdom
Funded under	H2020-MSCA-IF



© ARBUATEM

Innovative treatment system leads to cost-effective and eco-friendly manure management practices



In several European regions, the management of pig manure has become a serious environmental issue that demands solutions by the farming sector. However, most existing state-of-the-art solutions aren't technologically and economically viable.

In recent decades, the negative environmental impact of livestock production and manure handling has been controlled by stricter regulations for manure storage and spreading. Nevertheless, the intensification of livestock production has led to larger herds on fewer farms and industrial-scale operations that produce large quantities of manure at centralised locations.

As intensive livestock farming is being placed under increasing pressure to minimise the environmental impact of its operations, several methods have been assessed as best available technologies for manure treatment while improving nutrient resource use. Such procedures are neither technologically practical nor economically feasible. More importantly, they're usually subjected to national subsidies which prevent them from being profitable in the long term. As a result, pig installation owners must pay waste treatment companies for their pig manure management, and the larger installation owners have to invest in their own treatment equipment to comply with the regulations.

Leading-edge technology for cleaner, greener manure treatment

To address this need, the EU-funded DEPURGAN (Swine-farm revolution) project devised "an efficient pig manure treatment process," says project coordinator Mr Javier Melús. "The system is both economical and environment friendly."

DEPURGAN developed and patented a pig manure treatment system that's tailor-made to accommodate the needs of users. It's fully automated, expandable and can be implemented on one or more farms. The technology is suitable for



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"Thanks to DEPURGAN, the pig farming industry now has an all-in-one-solution that offers a quick return on investment thanks to lower operation and maintenance costs"

irrigation and farm cleaning. It doesn't generate greenhouse gases, gets rid of waste and doesn't pollute aquifers.

The DEPURGAN innovation minimises the concentration of contaminants like nitrogen, phosphorous, metals, bacteria and viruses in manure. These key components are also environmental hazards. In addition, it treats pig manure at its origin and valorises manure in terms of energy recovery and fertilisation.

Getting the most out of pig manure

To accomplish all this, the system performs a succession of physical-chemical treatments known as depuration. This includes homogenisation, solid-liquid separation by centrifugation, coagulation-flocculation and solid-liquid separation by electrocoagulation. The treatments help to obtain two residuals: solid and liquid. The solid residual is used for the manufacturing of pellets, with an equal mixture of manure and pine wood. The liquid residual is used for fertilisers in agricultural crops.

The DEPURGAN process eliminates viruses, bacteria and parasites, and removes odours and colours. It reduces heavy metals in water and nitrogen by about 99 % and up to 90 %, respectively, and chemical oxygen demand by nearly 95 %. By virtue of its high-efficiency power supply, electricity consumption is cut by close to 20 %.

"Thanks to DEPURGAN, the pig farming industry now has an all-in-one-solution that offers a quick return on investment thanks to lower operation and maintenance costs," concludes Mr Melús. "The system is also worthwhile financially for farmers because they don't have to depend on national subsidies anymore, and it also contributes to achieving a circular economy in rural areas."

Project	DEPURGAN - Swine-farm revolution
Coordinated by	Eurogan in Spain
Funded under	H2020-SME and H2020-ENVIRONMENT
Project website	http://www.depurgan.com/ingles/index.html

Europe's enforcement authorities and food industry empowered to tackle food fraud



New tools and resources have been developed to help European food producers spot counterfeit products and food-related fraud worldwide. This will add value to European products and help protect consumers both in Europe and abroad.

Europe's high food standards are being compromised due to incidences of fraud and counterfeiting in the food industry. The EU-funded FOODINTEGRITY (Ensuring the Integrity of the European food chain) project is encouraging food transparency and proposing better standards to minimise food fraud and ensure the integrity of the supply chain. "We're exploiting advanced techniques such as NMR spectroscopy, high-resolution Mass Spectrometry and Next Generation Sequencing coupled with advanced big data analysis to achieve the project's aims," says James Donarski, Head of

Food Authenticity at Fera Science Ltd, the UK company that's coordinating the project.

High-tech strategies to identify food fraud

Researchers are employing tools such as forensic accounting and paper audit trails to identify fraud issues, as well as social science to determine the impact of food fraud on consumers.

It is studying food authenticity practices to determine where further work needs to be commissioned. “We are improving data sharing related to food fraud by supplying methods and tools that will address both enforcement and industry needs,” states Dr Donarski.

The project is providing state-of-the-art capabilities to detect fraud and establishing a body of experts to inform high-level stakeholder platforms on food fraud issues. “We’ve developed verification methods and systems for three food commodities that are significantly affected by adulteration and fraud, namely olive oil, spirits and seafood,” reveals Donarski.

Nipping fraudulent activity in the bud

The consortium is currently developing several early warning systems that can detect fraud in a cost-effective proactive way. “These systems can alert food suppliers and retailers about developing issues worldwide and help them introduce mitigation procedures before a crisis develops,” explains Dr Donarski.

One such system detects anomalies such as sudden price changes, socioeconomic issues and/or climatic changes that provide lucrative opportunities for fraudsters. “A retrospective study of the horsemeat scandal, for instance, showed that the system would have picked up anomalies in trade and meat prices three to seven months prior to the scandal being uncovered,” highlights Dr Donarski.



“We’ve developed verification methods and systems for three food commodities that are significantly affected by adulteration and fraud, namely olive oil, spirits and seafood”

Other developed systems can monitor weblogs, news and medical journals in over 60 different languages and identify emerging issues worldwide. Another system is trained to predict the type of food fraud based on historical records. “With key information such as commodity type and country of origin, we can reliably predict what type of fraud we should expect,” adds Dr Donarski.



An array of new tools and resources

FOODINTEGRITY is now finalising a user-friendly open source knowledge base on authenticity/fraud detection methods. This includes the assessment of rapid methods for application within industry based on XRF, hyperspectral imaging, laser induced breakdown spectroscopy, NIRS and Raman. The project is also conducting cutting-edge research such as authenticating complex foods using protein signatures, employing microsensors and ICT platforms to ensure onsite authentication of high-end foodstuffs, and using smartphones to detect substitutions.

The project has also produced a study of Chinese consumers on how they perceive and purchase European food products, along with recommendations for European industry marketing products to Chinese consumers. FOODINTEGRITY will no doubt enhance food industry competitiveness and consumer confidence. It will contribute to a more responsible food system with respect to being ethical, transparent and accountable. It will put methods, systems and processes in place that will assure the quality, authenticity and safety of the food chain, which will strengthen the European agri-food sector altogether.

Project	FOODINTEGRITY - Ensuring the Integrity of the European food chain
Coordinated by	Fera Science Limited in the United Kingdom
Funded under	FP7-KBBE



Urban food from vertical farming

Your local supermarket and favourite restaurant could soon be growing their own food, thanks to an EU-funded project that has completely redesigned the food supply chain to develop the concept of in-store farming.

Our busy, modern lives demand that fresh produce be available 365 days a year, even though some varieties may only be seasonal and/or produced on the other side of the world. The result is a food system centred on quantity, low prices and efficiency rather than on quality, sustainability and traceability.

The EU-funded INFARM (The vertical farming revolution, urban Farming as a Service) project reflects a growing desire for highly nutritious locally grown food, which is free of herbicides and pesticides and addresses the lack of accountability in the current food system. "By growing produce directly where people eat and live, we can cut out the lengthy supply chain, significantly reduce food waste, offer nutrient-dense food without any chemical pesticides and improve the environmental 'foodprint' of our plants," says the INFARM's Chief Technical Officer and co-founder, Guy Galonska.

The answer lies in vertical farming, which grows food in vertically stacked layers under carefully controlled conditions, using hydroponics and light-emitting diodes (LEDs) that mimic sunlight. INFARM takes the concept a step further by employing its smart modular farming units throughout the city "Rather than asking ourselves how to fix the deficiencies in the current supply chain, we wanted to redesign the entire chain from start to finish; Instead of building large-scale farms outside of the city, optimising on a specific yield, and then distributing the produce, we decided it would be more effective to distribute

the farms themselves and farm directly where people live and eat," Galonska explains.

Use of technology

Each farming unit is its own individual ecosystem, creating the exact environment for plants to flourish. By developing the optimal light spectrum, temperature, pH, and nutrients researchers can ensure the best possible flavour, colour and nutritional quality for each plant, whether it be rocket from Provence, Mexican tarragon or Moroccan mint.

The distributed farms are connected by INFARM's central farming platform, creating a first of its kind farming network: "Each farm acts as a data pipeline, sending information on plant growth to our platform 24/7 allowing it to learn, adjust and optimise." A matrix of sensors collects and record data, enabling researchers to remotely optimise the growth of the plants in real-time. This information is also fed into the central farming platform, ensuring its continual development and improvement.

The design of the growing trays mimics the petal pattern of the sunflower, which represents the most efficient arrangement of space in nature. The tray moves plants from the centre to the outer perimeter according to their size and growth. Young seedlings are placed in the centre of the spiral and are harvested





“We wanted to redesign the entire chain from start to finish”

from the outside when matured. This design allows fresh produce to be harvested each day at a significantly higher output than comparable technologies.

Supply chain reduced

INFARM is now operating more than 50 farms across Berlin in supermarket aisles, restaurant kitchens and distribution warehouses. In addition to the in-store farms, INFARM has successfully installed and activated a large-scale seedling plant and logistical support system that allows the continued, successful operation of all farming units.

These results are the first step towards creating an urban farming network in Berlin that will ultimately make the city more self-sufficient in its food production. According to Galonska: “With our system, we have completely reduced the food supply

chain, as our produce is grown in the heart of the city, often directly at points-of-sale. Thus, customers can purchase fresh produce, minutes after being picked, thereby retaining all its original nutritional qualities, which are lost when the produce is transported and refrigerated.”

Those benefiting from the work of INFARM range from small grocers to global retail conglomerates and governments interested in water conservation, food security and reducing greenhouse gas emissions. Galonska concludes, “INFARM’s innovative business model has attracted major interest and I believe that our success will serve as proof, to both aspiring entrepreneurs and established companies, that going ‘green’ can be profitable and sustainable.”

Project	INFARM - The vertical farming revolution, urban Farming as a Service
Coordinated by	INFARM – Indoor urban farming GmbH in Germany
Funded under	H2020-SME and H2020-FOOD
Project website	https://infarm.de

New policies and innovations to boost European seafood sector



The taste for European seafood is steadily increasing both at home and abroad, but environmental pressures are compromising supply which is dependent on fisheries and aquaculture. A more sustainable and financially viable model is therefore needed in Europe’s seafood sector.

Europe is looking to strengthen the competitiveness of its fisheries and aquaculture industries to meet increasing demand. Against this background, the EU-funded SUCCESS (Strategic Use of Competitiveness towards Consolidating the Economic Sustainability of the European Seafood sector) project worked on strengthening the competitiveness of the European fisheries and aquaculture industries by conducting key research along the full value chain, i.e. from the fishing net (producers) to the plate (consumers).

This couldn’t have come at a better time since growing environmental concerns have begun to affect consumer purchasing behaviour. “Consumer preferences for seafood vary considerably among countries and markets,” says Dr Bertrand Le Gallic,

Assistant Professor in Economics – University of Brest, France, which coordinated the project. “There is certainly a market for sustainably and locally produced seafood, presenting an important opportunity for the producers,” he adds.

Good results on the ground

Competitiveness can be achieved by enhancing cooperation among producers, processors and relevant organisations and by differentiating the product based on quality, origin, processing and convenience. In one case study the project enhanced cooperation among scallop producers in Galicia, Spain, bringing producer organisations closer to



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processors to create a fresher, more premium product. “The fishermen sell the company at a negotiated price, which beats selling by auction, yielding a high-quality product,” illustrates Dr Le Gallic.

The project also demonstrated the importance of convergence in aquaculture between key European countries and non-EU countries such as Turkey. “Non-EU companies don’t necessarily need to comply with the high EU standards at production level,” states Dr Le Gallic. In some cases, establishing safeguards such as non-tariff measures can protect against unfair competition.

SUCCESS also highlighted the need to address lack of information across the seafood value chain regarding quality and benefits. “Increasing and improving communication regarding quality and product at every level of the value chain can benefit both producers and consumers,” insists Dr Le Gallic, highlighting the example of a training programme developed by the Spanish government for working at retail seafood counters.

Recommendations for better policies

SUCCESS identified a need for policies to address the heterogeneity of the seafood value chain. “Since the seafood industry is well diversified by species, countries and production systems, it can benefit from more tailored policies, as generic policies may be ineffective or even harm the industry,” says Dr Le Gallic.

There is also a need to improve consumer knowledge and traceability, particularly in places where consumers aren’t very familiar with seafood products. An example from Dr Le Gallic involves “introducing labels of origin on seafood as many consumers would be willing to pay more for differentiated products from specific countries.”

Overall, the EU can simplify legislation and promote policy coherence for advancing aquaculture, e.g. through an enhanced regulatory framework. This includes, for example, fairer implementation of Marine Spatial Planning to avoid competition with the tourism sector. Simplifying licensing procedures and harmonising environmental

impact assessments would also be useful, so would facilitating regulations to establish new industry facilities.

Coherence between EU quality schemes and EU organic labelling – such as shellfish farming – is pivotal, so is promoting innovation in the field. One SUCCESS partner developed new innovative mussel products using natural preservatives. “The extended shelf-life of these products helps producers to reach remote markets and compete with imported mussels in the domestic markets,” says Dr Le Gallic.



“There is certainly a market for sustainably produced seafood, presenting an important opportunity for the producers”

Lastly, measures should be put in place to compensate for positive societal impacts at the expense of the fishing industry. Examples include losses in carp due to predators from protected birds or due to touristic attractiveness of an area which limits aquaculture and fishing.

There is no doubt that policies and innovative products can render the sector more competitive and sustainable.

Project	SUCCESS - Strategic Use of Competitiveness towards Consolidating the Economic Sustainability of the European Seafood Sector
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