Institution: University of Plymouth

Unit of Assessment: UoA06 Agriculture, Veterinary and Food Science

a. Context.

Research in this UoA addresses the issue of sustainable, food production, food security and environmental protection for multiple stakeholders in the academic and non-academic communities. Our research relates to the needs of farmers, industry, and policy makers, and we aim to provide underpinning evidence and decision support for land managers, including both farmers and conservation bodies. We also undertake research that is more directly focussed on commercial producers of food crops, the animal feed industry, and companies involved in crop protection through biocides and pesticides or novel products with intended use in agriculture, such as nanotechnology. Our research provides information on safety for substances used in agriculture and is also directed towards Government to influence agricultural and environmental policy and/or inform regulation of the risks to the environment or human health especially in the areas of aquaculture, nanoscience and water quality.

b. **Approach to impact**.

We adopt a planned approach to achieving impact with our research. Our research is principally applied research focussed around the enhancement and protection of the land and water based human food chains. This means that there are routes to impact for almost all of our research projects. Choice of research projects is driven by a needs analysis of the food and environment industries and by our on-going direct engagement with policy makers such as DEFRA, the OECD, the Water Industry, and the Environment Agency. International reach is promoted through collaborations with government agencies such as Agri-Food Canada, CSIRO, the Department for Primary Industries Australia, Agriculture Research Service-USDA, Environment Canada, the Finnish Safety and Chemicals Agency, the US Army Engineer Research & Development Centre Vicksburg, and the Swiss Federal Institute of Aquatic Science and Technologies (EAWAG), and with multinational companies such Alterra (Netherlands), Altech (Ireland) and the Nanoscience Consortium (Canada).

All projects, including both funded research and PhD projects, are required to define their potential impact and identify pathways to impact. This is reported and considered as an integral part of the peer-reviewing of funding applications undertaken at Research-Centre level and in conjunction with our Research and Innovation Division's Engagement and Commercialisation advisers. We reach end-users through project steering groups and, more generally, we organise open research meetings where we present our latest work to mixed audiences of practitioners and academics. These processes facilitate discussion with end-users, leading to new collaborations, contract research, and KTP proposals.

The impact of our research and its outputs are monitored at Research-Centre level. We measure success in academic terms through publications in high quality journals and citations and encourage all of our researchers and research students to join academic network dissemination platforms such as ResearchGate. Internally we celebrate impact successes and disseminate these through our Research Centre websites and internal workshops and seminars. For researchers in training we insist on the cataloguing of outputs and public engagements in an individuals' research degree thesis and in an appendix to their European Commission Diploma Supplement. All PhD theses and journal articles from 'Gold' and 'Green' open access publishers are archived to the University's digital repository 'PEARL' with free download online.

Regional impact involves small or medium sized enterprises in the agri-food supply chain and these are difficult to engage with individually. We therefore engage with groups of farmers and other partnerships in order to ensure sufficient critical mass to sustain research endeavour and find solutions. This is often through the Levy Board(s) on identified priority problems. We have also built partnerships with regional organisations that pursue such interactions as part of their business remit. These include, the Rural Business School at Duchy College, ADAS, North Wyke Research Farm Platform, and NIABTAG, and environmental consultancies such as WCA Environment.

Members of the UoA have been integral in establishing and maintaining The Southwest Rural Enterprise Gateway as a service to support farming groups in developing focussed strategies and to access knowledge and expertise at the University and to translate this into real-life business solutions to farming challenges. An extension of this was the establishment of the Peninsula Partnership for the Rural Environment with our regional partners at Exeter University, Rothamsted Research North Wyke, and Duchy College. This partnership has assisted in the development of a

body of complementary expertise through which research competency at Plymouth has been developed and applied to farming and rural community research applications. We strategically invested ESF funding in the joint supervision of 30 Research Masters students at Duchy College in order to enhance the impact to farmers, growers and rural communities both regionally and nationally of the RDPE Healthy Livestock project, the DEFRA Farm Business Survey, and the Duchy Organic Centre. Joint supervision by members of the UoA and Duchy staff has helped build research capability and capacity in the SW region and to disseminate research results to farmers, growers, and rural communities, both regionally and nationally.

Industrial companies are direct sponsors of many of our research projects, knowledge exchange being assured by this engagement. This is particularly the case in aquaculture, where we have a strong international reputation and where research outcomes are used directly by major animal feed suppliers such as AllTech and Mars. Industry involvement is also manifest through collaborative research projects under LINK programmes and through Technology Strategy Board engagement in Knowledge Transfer Projects (KTPs) and other research. In these ways, a substantial part of our research has a ready-made pathway to impact, with outcomes made directly available to end-users through reports, extension summaries, and the implementation of decision support systems.

Whenever a major policy change is published that maps to our strengths, we engage directly with the policy or implementation body to provide consultancy and focussed research to evaluate and disseminate research results. This has been particularly apparent in relation to managed landscapes and how they impact on water quality. An example is the EU Water Framework Directive (WFD), where we have assisted the Water Industry and the Environment Agency by assessing the impacts on water quality arising from the persistence and effects of metals in mine-water drainage in the Tamar Catchment and of faecal indicator organisms from livestock within the Caerhays catchment. The project required the development of GIS methods and Simcat models to identify and quantify sources of priority chemicals and nutrients to the aquatic environment. The export coefficients and graphical outputs comprise a tool that has been applicable for sources of a variety of chemicals at waterbody resolution across England and Wales. This tool has been further developed for the second cycle of river basin planning to support future programmes of measures under the WFD.

We have also designed, costed, and provided guidance and data analysis for an industry-wide chemical investigation programme, amounting to over £30 million, into the sources, treatment and compliance of priority chemicals received and discharged from sewage treatment works in order to provide data for catchment planning under the WFD. Over 180 sewage works' effluents were sampled over the course of 1 year: 28 sewage works were sampled for crude sewage, primary, secondary and tertiary treatment wastewater over a 1 year period and 10 town sewer catchments were sampled (amounting to 1000 samples at each) to identify sources of metals, nutrients, organics and sanitary chemicals, including domestic, industrial, light industry and commercial waste waters.

c. Strategy and plans.

Our aim is to continue to place impact at the heart of our strategy and our research will increasingly be delivered through engagement directly with stakeholders to deliver policy, economic and societal change that leads to greater environmental sustainability. To achieve our strategy we plan to target research funding opportunities and invest internal funding that enables us to answer meaningful research questions affecting the food production chain. To achieve this each of our research proposals will continue to be peer reviewed and will be required to include a pathway to impact statement and to identify stakeholder engagement and will influence the prioritisation of applications. Outputs from our research projects will be monitored for their impact in peer reviewed journals by tracking journal impact factors and citations and we will increasingly publish through reputable Open Access sources as we recognise this as being key to greater dissemination and uptake of our findings. Staff will be encouraged and rewarded to focus on team approaches to their research efforts with goal oriented research that addresses food security and food safety, and environmental protection. Our target is to generate the equivalent of a REF Case study per year which demonstrates the impact of our research and these will be showcased in the public domain through virtual media platforms. We plan to embed the impact culture in our researchers in training (PhD students) and we deliver research impact training so that we are well

placed to produce the next generation of researchers who are fully engaged with the impact agenda.

Our impact strategy involves the **monitoring of the pathways to impact** statements produced at the beginning of each project and assisting the facilitation of these pathways. We assess whether or not each project has the potential for exploitation and protect intellectual property where appropriate and then exploit this using the infrastructure provided by our Research and Innovation support teams and we aim to produce at least one patent application per year. Where research outputs have the potential to influence Governmental policy or regulation change we will continue to support these researchers to engage with the appropriate bodies through our existing contact channels and through financial support and time allowance to attend National/International Committees, Enquiries and Think-tanks.

We will continue to seek funding from a range of funders including research councils, industry, levy boards and the European Commission and ensure that applications are supported by our Peer Review system which includes an Ethics review and a Pathway to Impact review.

The dissemination of our research outcomes includes a publication strategy linked to our impact strategy where we encourage both publication in journals with high impact factors which are well cited and those which we know are read by applied scientists. Furthermore, we encourage the distillation of research outputs for publication in trade journals and articles that will be read by stakeholders involved in the agric/aqua food chain and policy makers.

d. Relationship to case studies.

The 3 case studies chosen for inclusion in this submission exemplify various aspects of our strategy and approach to impact involving scientifically driven research in partnership with industry and leading to governmental policy changes, the implementation of regulation and the spin-out of intellectual property. Reflection on the cases has informed our review and revision of the strategy and approach.

The nanoparticles study illustrates how the scientific discipline of ecotoxicology can be applied to evaluate the safety and environmental impact of an emerging and largely untested technology that has been heralded as a major breakthrough in revolutionising the delivery of feedstuffs and agrochemicals. The likely impact of this technology was identified and its dissemination in key publications in the scientific literature had immediate resonance worldwide with policy formulators and led to an invitation to write the first definitive review of the environmental threats of this emerging technology. This then led to the convening of advisory panels, further research grants and the production of further evidence that has led to many seminal reports of the influences and dangers of nanoparticle release that have shaped inter-governmental policy.

The aquaculture nutrition study illustrates how a research team with a clear pathway to impact approach and working closely from the outset with industry on policy grounded research has led to fundamental and applied results that have delivered reduced production costs, enhanced yield and product quality, and improved competitiveness. The research demonstrates how a thorough scientific approach at both the whole organism level and through an understanding of the molecular control of regulation of key biological processes has led to the overturn of a blanket governmental ban and to industry applications that have influenced animal diet formulations and identified challenges to the wider industry. The work also demonstrates how scientific reputation is built leading to invitations to sit on national and international decision boards to inculcate scientifically based judgement to policy and the regulation of feedstuff formulations.

The PoreCor/PoreXpert study is an example that illustrates the cross-talk between fundamental scientific understanding and its applied industrial research applications**.** It demonstrates how fundamental soil science research has cross-disciplinary applications and shows how we both protect and exploit in-house intellectual property for the benefit of the research field, the individual developers and the industrial users of such innovation and how we interact with and utilise the expertise of our professional Research and Innovation support teams.

The choice of these illustrative case studies demonstrate the translation of science into practice and the influence of research carried out by our UoA on industry, policy, legislation, safety and regulation leading to improved production and the protection of the environmental base for sustainable agri-food production. They exemplify the successful impact of our research and provide exemplars for future projects and we have disseminated these amongst our researchers and plan to learn how to further emulate the approach they have taken.