CRP RESEARCH THEMES

Context for Policy Relevant Science

The overarching challenges facing agriculture, food, fisheries and forestry research are *food security* and *nutrition* – the world will need to balance food production and food demand for a population of at least nine billion in 2050 – and *sustainability* – of the world's natural capital as well as its food production systems. These become the key outcomes for the CRP investments.

In order to deliver on these overarching challenges, the CRP has identified three pillars, or themes, set in the context of globalisation and climate change:

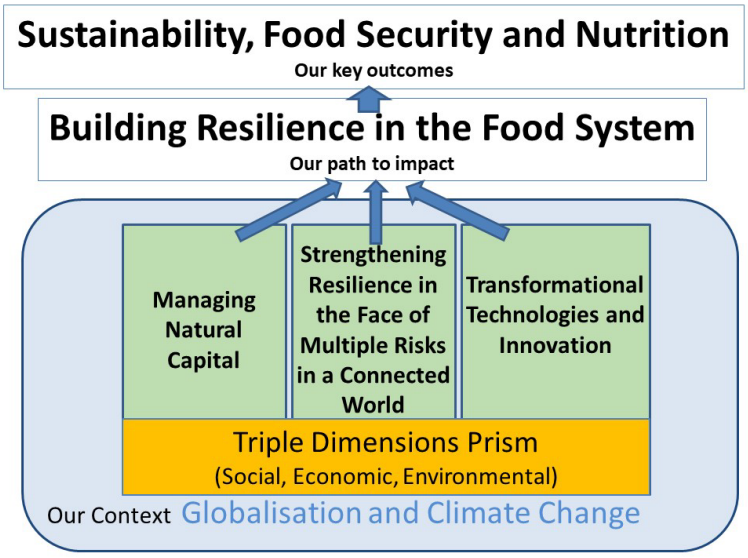
I. MANAGING NATURAL CAPITAL

II. STRENGTHENING RESILIENCE IN THE FACE OF MULTIPLE RISKS IN A CONNECTED WORLD

III. TRANSFORMATIONAL TECHNOLOGIES AND INNOVATION

Global issues, such as food security and climate change and the growing connectedness of economies through trade and travel, need to be addressed by developed countries participating in the CRP and by developing countries alike. Consequently, many of the issues dealt with through CRP activities can have much wider relevance and impact than just the CRP membership.

This schema is illustrated below:



All applications for CRP funding – for both conferences and fellowships – need to be relevant to one (or more) of the three research themes of the CRP.

Detailed description of the research themes are below.

Theme I. MANAGING NATURAL CAPITAL

This theme is about how to manage natural capital by making secure the availability and managing the quality of natural resources.

Land Healthy functioning landscapes, with their links to the urban environment, have multiple roles and deliver a range of services to society some of which are non-economic and intangible in nature. This includes, but is not limited to, leisure, health, tourism and biodiversity conservation. Key services provided by landscapes include the stabilisation of water resources, significant buffering of climate through carbon sequestration of soil and the role of vegetation cover in addition to agricultural productivity. In many systems, agriculture is the dominant land use and is then integral to maintaining functional landscapes that deliver such services to society.

Management of landscapes and therefore ecosystems is an important challenge with clear implications for agriculture. Scale of impact, different uses of space, competitive claims from different user groups, and the economics of land use all affect the way agriculture is positioned in the policy mix being applied to terrestrial space. There are also major competitive forces with respect to the agricultural vs. non-agricultural uses of space.

Soil "Essentially, all life depends upon the soil. There can be no life without soil and no soil without life; they have evolved together." (Charles E. Kellogg, quoted in USDA Yearbook of Agriculture, 1938). Agricultural soils provide the foundation for productivity and are an increasingly limiting resource. Inappropriate or exploitative production systems represent a key threat for soil degradation through erosion, nutrient depletion or structural collapse. While some of these threats are reversible, some are not. Potential research areas might include understanding soil processes, rhizosphere and plant-soil-microbe interactions, carbon and nitrogen fluxes, structural properties of soils and the interactions with organic matter and inorganic nutrients, all of which may interact to influence plant health and productivity.

Water Agriculture is a major user of water and in some regions and for some crops may be the primary user. Falling water tables means that water is increasingly being mined, and not replenished. Agriculture is a key driver in the water dynamics of catchments and its total water use may be seriously depleting water availability and impacting on quality and water ecosystems. This nexus is becoming a widely recognised problem that needs to be underpinned with appropriate agriculture and food policy research to build sustainable water management strategies, reducing water usage through new technologies and practices, and better evaluation of water footprints.

Biodiversity Biodiversity issues are increasingly coming to the forefront of the agriculture, forestry and fisheries policy debate. Modern management practices coupled with climate change and other human activities (e.g. urbanisation) put consistent pressures on biodiversity. The resultant loss of biodiversity not only threatens the functioning of terrestrial and marine ecosystems, but also the capacity of society to adapt to certain challenges (e.g. diseases). It is therefore important that management practices take into consideration the protection and enhancement of biodiversity and that policies are being brought to bear so as to define the limits of tolerable impacts. Two particular areas of concern with respect to biodiversity are the identification of "subsidies" harmful for biodiversity and how to deal with property rights for genetic resources (i.e. the conservation and sustainable use of biodiversity for food and agriculture).

Forests Forests, when sustainably managed, provide wood biomass and an important carbon sequestration service to society over and above social amenities, water retention, biodiversity and the environmental protection of land. Maximising benefits from sustainable forestry in a multifunctional landscape can contribute to climate change adaptation and mitigation, water quality/flood mitigation, prevention and control of damage from pests and diseases, enhancing tolerance to abiotic stresses, solutions for sustainable management and intensification, tree improvement and forest genetics. The smart and effective use of wood biomass without waste remains an issue in all countries.

Aquaculture and Fisheries The marine and fresh water ecosystems are important providers of food and bio-energy products. Given pressures on terrestrial ecosystems it would be advisable to increasingly focus on the ability of the oceans to reduce the stress on the productive capacity of the terrestrial ecosystem, while recognising that some marine and fresh water ecosystems are already under pressure. Sustainable aquaculture, in which inputs and outputs along the whole production and supply chain are optimised, will be increasingly required. The sustainable management of fish stocks and aquaculture, safe sustainable solutions for fish feed, and understanding nutritional and environmental impacts of different farmed fish species are key challenges.

Integrated Agricultural Production Systems Managing the natural resource base and other inputs needs to occur in a systems context which seeks to optimise productivity but maintain sustainability through a healthy natural resource base including biodiversity. This science area provides opportunities for systems modelling and integration studies which also consider the socio-economic, as well as biophysical, dimension of agricultural production. There is a growing demand for products produced with sustainable farming practices (e.g. organic farming, no-till farming, agro-ecological principles). To cope with growing constraints of soil and water resources, it will be imperative to establish pathways for sustainable intensification of agricultural production in both plant and animal systems. Overall, a diversity of efficient, productive and environmentally sustainable agricultural systems will be required to meet food security challenges.

SCIENTIFIC ADVISORY BODY MEMBERS with responsibility for this Theme (Theme Co-ordinators)	
Prof. Paloma MELGAREJO NÁRDIZ National Institute for Agricultural and Food Research and Technology (INIA-CSIC) Department of Vegetal Protection Ctra La Coruña km 7.5 28040 Madrid Spain E-mail : melgar@inia.csic.es	Dr. Maria Joao SANTOS Assistant Professor of Earth System Science Department of Geography University of Zürich 8057 Zürich Switzerland E-mail: maria.j.santos@geo.uzh.ch

Theme II. STRENGTHENING RESILIENCE IN THE FACE OF MULTIPLE RISKS IN A CONNECTED WORLD

A key dimension of resilience is the ability of the sector to anticipate and respond to different types and levels of risk, whether the origin is market, resources or climate. Agriculture, food production systems, fisheries and forests are exposed to risks from several sources ranging from biosecurity risks (invasions of alien species leading to increased pest and disease risk or emerging infectious diseases which may impact on animal and human health), to climate related risks (adverse weather events such as floods and droughts which directly impact on agricultural productivity), and longer term climate change impacting on the potential of agricultural systems to achieve food security. Such risk factors may directly impact on productivity or disrupt trade and market access. Interest in agricultural risk management has become more prominent in global policy discussions, with more countries providing financial support for risk management tools in their agricultural policy frameworks.

Risk assessment Simple, easily accessible risk assessment tools are essential to help governments and managers of agricultural systems to anticipate, avoid and react to biosecurity, climate or market access risks and so minimise impacts at local or country scale. A number of approaches for risk assessment, pest risk mapping and related tools are available, but further refinement and application of these tools are needed for alerting policy makers and advising how policies should be devised at a larger scale.

Invasive Species and Biosecurity With increasing global interactions across countries and continents, invasive alien species are increasingly a challenge and the importance of biosecurity preparedness and risk assessment is growing. Invasive pests and diseases threaten both agricultural and forest productivity and biodiversity within countries and constrain the potential for free trade and market access. Marine biosecurity is likewise critical for the protection of aquaculture developments and marine biota itself. Biosecurity science is about securing social, environmental and economic wellbeing by minimising the risks of pests and diseases and enhancing the effectiveness of mitigation and eradication responses. Understanding the global spread of these pests and diseases, early detection and assessment to develop appropriate policy responses are crucial for modern societies. In addition, transparent science based policy and support mechanisms will enhance opportunities for free trade.

Food safety Food safety is an essential public health function as are healthier diets and nutrition, sustainable consumption and healthy eating, and technology/processing aspects of food and feed. It encompasses actions aimed at ensuring that all food is as safe as possible, throughout the entire food chain from production to consumption. For the CRP, relevant science will underpin improvements in food safety along the food chain.

Emerging Diseases From a human perspective, the emerging issues of pathogens transmitted from animals to humans (zoonotic diseases), or directly to humans, animals and crops, can have devastating effects across the globe within a short time span. Likewise the emergence of new disease threats to major commodity crops represents real vulnerabilities to global food security. With the worlds reliance on a small suite of crops and livestock species (e.g. 95% of all calories consumed are derived from just 11 crops) the spectre of new diseases which threaten productivity and human health require pre-emptive science and policy action.

Antimicrobial resistance Antimicrobials are used in various applications including human and animal medicine, food production, plant agriculture and industrial applications. Over the last decades the emergence of antimicrobial resistance (ARM) associated with widespread use of antimicrobials in the livestock sector, as well as other factors relating to their use in human health, means that it is of the utmost importance to preserve the efficacy of antimicrobials for future use, and therefore crucial to fill information gaps about current use and effects and to develop alternative management strategies which minimise reliance on their use.

Climate risks to production Climate change and climate variability pose significant risks to the sustainability of farming enterprises globally but with particular consequences for the productivity of subsistence or marginal agriculture in resource poor economies. A response to climate constraints requires well integrated efforts to capitalise on existing and new technologies for crop or livestock improvement explore adaptation and mitigation opportunities in the wider context of profitable, sustainable and resilient farming systems.

SCIENTIFIC ADVISORY BODY MEMBERS with responsibility for this Theme (Theme Co-ordinators)	
Dr. Se-Yeoun CHA Jeonbuk National University College of Veterinary Medicine and Center for Poultry Diseases 79 Gobong-ro Iksan 54596 Republic of Korea E-mail: seyeouncha@jbnu.ac.kr	Dr. Michael J. ROTHROCK Research Microbiologist and Lead Scientist USDA-ARS, US National Poultry Research Center 950 College Station Rd. Athens, GA, 20605 United States E-mail: michael.rothrock@usda.gov

Theme III. TRANSFORMATIONAL TECHNOLOGIES AND INNOVATION

The agriculture and food system has a long history of innovating and adopting new technologies to increase productivity, manage risk and improve environmental, social and economic sustainability.

Digital Technologies The use of digital technologies and related innovation – by farmers and also by policy makers and administrators – offers new opportunities but also brings new challenges. These new opportunities are particularly important in the context of the challenges of climate change and in an increasingly integrated global food system. Emerging digital technologies are transforming production and distribution systems and opening up un-imagined possibilities for understanding and accessing markets, for improving sustainability and productivity, and for linking consumers and producers along the entire supply food chain. The use of GPS techniques, special mapping, equipment guidance techniques and robotics open up opportunities for controlled traffic and spatially differentiated and optimised inputs and management. This optimisation can lead to more effective management of soil resources and considerable decreases in inputs be it through smart uses of fertilisers, water or pesticides. Moreover, with the increasing pressure for sustainable intensification of livestock production systems in particular comes the imperative for precision nutrition which optimises growth and minimises waste. Digitalisation also provides new ways of improving policy design, implementation, measurement and monitoring of outcomes. However, adoption of new digital tools for policy risks creation of a "digital divide" between those who can access or use the tool and those who cannot.

The capacity to create value in the agri-food system using digital technologies depends on a wide-range of factors including: i) access to basic connectivity infrastructure (broadband, telecommunication services); ii) data collection, storage and analysis services (sensors, modelling, digital platforms, software systems for managing and processing data); and iii) the regulatory environment (the institutional environment defining data quality standards, norms or regulations on data ownership and data privacy). Research in support of all aspects of digital agriculture is therefore an important specific area for CRP consideration.

Advanced breeding tools/Genetic and genomic technologies The continued development and application of genetic/genomic tools, including precision genome editing, and biotechnology offers significant opportunities for enhanced crop and livestock breeding which can directly address agricultural productivity constraints, and issues related to food security, human nutrition and health. At the same time genetic technologies may reduce stresses on natural capital including soil and water, and contribute significantly to green growth by increasing productivity and reducing externalities of production. Consumer acceptance of such innovative approaches will also need to be taken into account.

Novel waste reduction technologies An important part of global food production is lost after harvest and before reaching consumers. In many developed economies a substantial amount is wasted after purchase by consumers. Addressing these losses represent the "low hanging fruit" in addressing food supply on the path to food security. Innovative approaches to waste through recycling and optimising nutritional demand combined with innovations in post-harvest crop losses will provide significant benefits.

Biofuels The transition away from energy based on fossil fuels to more renewable energy sources is an important contribution to climate change. Biofuels, second generation and/or based on marine algae are promising avenues for reducing carbon emissions, but introduce the potential for conflicts in food supply when food crops or arable land used for food production are redirected into biofuel production. Addressing these conflicts with effective policy instruments is an important and ongoing area where science can help provide alternative options.

Bioproducts and Bioprocesses There is a growing demand from the private sector in bio-products derived from biologically based feedstocks and bioprocessed on an industrial scale to generate high value products as part of the developing bioeconomy. There is considerable need for innovation here, not necessarily through investments in the processes themselves but through consideration of whole of supply chain integrity and sustainability of a bioeconomy in the context of landscapes practising agriculture producing food and fibre. The importance of system biology and synthetic biology in understanding the biological processes and developing effective production chains of bio-products are important in this regard.

Innovations in Social Science, Economics and Education Achieving outcomes of agricultural sustainability and resilience in a resource and climate constrained world requires some particular innovations in the social and economic sciences and in educational support for agriculture, environment and food sciences. Such innovations will be important to facilitate the translation of science knowledge into outcomes and change at the level of policy development, policy implementation and adoption of new practices by stakeholders to achieve productivity growth and protection of natural capital. Addressing these areas will allow the CRP to directly support OECD's work on innovation, productivity and sustainability of agriculture and food system and similar global initiatives.

SCIENTIFIC ADVISORY BODY MEMBERS with responsibility for this Theme (Theme Co-ordinators)	
Dr. Lieve HERMAN Unit Head - Technology and Food Science ILVO - Flanders Research Institute for Agriculture, Fisheries and Food 9090 Melle Belgium E-mail: lieve.herman@ilvo.vlaanderen.be	Dr. Andy SHEPPARD CSIRO Health & Biosecurity Research Director Clunies Ross Street Acton ACT 2601 Australia Email: andy.sheppard@csiro.au