

Agri-Food Industries & Rural Economies
Competitiveness & Sustainability
the
Key Role of Knowledge

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EXECUTIVE SUMMARY

1. In response to the ongoing reform of the Common Agricultural Policy, EU enlargement and more liberal world trade in agricultural products, allied to increasing society/consumer demands, as well as other policy developments and international drivers of change (Section 2), Europe's agri-food industries and rural regions will be radically transformed in the coming decade.
2. Following the fundamental reform of the Common Agricultural Policy (Luxembourg, 2003), the overall policy framework has, as outlined in Section 4, shifted towards rural development, involving the
 - Development of an internationally competitive multifunctional European agriculture, producing market-required food products and environmental goods and services
 - Diversification of the economies of rural regions throughout the enlarged EU
 - Protection and management of Europe's rich heritage of rural landscapes and cultural diversity
3. As sectors inherently based on the exploitation of natural resources, Europe's agri-food industries are confronted with virtually unique challenges by the two overarching EU goals of *Competitiveness and Sustainability*.
4. Countries that achieve the optimum balance between the economic dictates of profitability in agriculture, and at the same time address environmental and consumer concerns, will have internationally competitive agri-food industries in the coming decades. *Knowledge is the key to attaining this crucial balance.*
5. EU agriculture and rural regions must be repositioned in the knowledge economy, by developing knowledge-based multifunctional agri-food industries and rural economies.
6. This will require a new conceptual framework or paradigm for EU research in agri-food, the environment and rural economies. As discussed in Section 5, this should involve a two-dimensional research strategy, comprising *Transition* and *High-Tech Research Programmes*. The two programmes should be designed so as to support both the competitiveness and sustainability of the EU agri-food industries and rural economies.
7. ***The Transition Research Programme*** is envisaged as being more concerned with sustainability, in the context of the shift from the volume/output bias of the former Common Agricultural Policy to the more consumer/society multifunctional reformed Common Agricultural Policy.
8. ***The High-Tech Research Programme*** should be more concerned with competitiveness in the context of freer world trade in agricultural products, following the ongoing WTO negotiations.
9. To illustrate the general scope and thrust of the two dimensions of the proposed research strategy, Indicative Research Portfolios are presented in Section 6 for the *Transition Research Programme*, involving consumer demands, food for health, new models of production systems, sustainable rural economies, regulatory framework, rural innovation and policy developments; and for the *High-Tech Research Programme*, involving plant sciences, animal sciences, environment, diagnostics, and pharmaceuticals.

1. Introduction

*Competitiveness and Sustainability*¹, the two overarching EU goals, present formidable socio-economic challenges for Europe's agri-food industries and rural economies.

The functionality of European agricultural systems, the management of the rural environment and the future sustainability of rural regions throughout the enlarged EU, involve a complex array of interactions between the domains of agriculture, food, health, the environment, land-use, society and the economy. In response to the continuing reform of the Common Agricultural Policy, EU enlargement and liberalisation of world trade, allied to increasing society/consumer demands and other drivers of change (Section 2), Europe's agri-food industries and rural regions will be radically transformed in the coming decade.

The rural economy is not a geographically separate entity and, in the coming decade, the functional interdependencies between rural and urban areas will become much more pronounced. The changing face of rural Europe and the complexity of challenges involved in the sustainable development of rural regions and their research knowledge and infrastructure needs are documented in the Foresight Blueprint entitled *Agriblue – Sustainable Territorial Development of Rural Regions of Europe* (EUR 21259), recently published by the EU Commission (2004). (This will henceforth be referred to as the Agriblue Foresight Blueprint.) Provision of the knowledge-based understanding of the multifaceted interactive array of policy developments, drivers of change, competitiveness and sustainability issues involved will require a new conceptual framework for agri-food research and related areas, in terms of strategic direction, capacities and governance.

2. Policy Developments & Other International Drivers of Change

An overview of EU policy developments and their implications for Europe's regions is presented in the Blueprints for Foresight in Regions Synthesis Report, entitled

¹ These terms are used in the context of the EU policy developments outlined in Section 2.

Foresight and Transitions to Regional Knowledge-Based Economies (EUR 21262) published by the EU Commission in 2004. Among the major policy developments and global drivers of change that will determine the future international competitiveness of Europe's agri-food industries and the sustainability of rural regions, the following are of paramount importance:

- i) Ongoing reform of the EU Common Agricultural Policy, allied to EU enlargement
- ii) The outcome of negotiations under the World Trade Organisation (WTO), resulting in more liberal world trade and greater globalisation of markets, including agricultural products
- iii) The EU Lisbon Strategy and the need to re-position Europe's agricultural and food industries and other rural businesses in the knowledge economy, is of central importance in reconciling the seemingly conflicting demands of competitiveness and sustainability
- iv) The increasing competition from scarce natural resources, in particular water, fossil fuels and space
- v) The rapidly changing policy framework, combined with the growing competitive climate, demand the production of food products of assured safety, consistent quality and health-promoting attributes, produced in a manner compatible with environmental and animal welfare requirements
- vi) The projected population growth (2-3 billion), combined with the greater prosperity of some social groupings will lead to increased crops and livestock production, possibly of the order of 40%
- vii) Emerging markets in Latin America and Southeast Asia may effect EU animal production, especially in poultry and pork
- viii) With added value being increasingly created by the processing industry and the retail sector, the economic and social power of primary producers will be progressively eroded
- ix) The decoupling of economic growth from environmental degradation, envisaged in the EU Strategy for Sustainable Development, together with compliance with EU Environmental Directives (Nitrogen Vulnerable Zones, Water Framework and Strategic Environmental Assessment) and also with international environmental agreements, notably the Kyoto Protocol, will require an EU-wide response, in terms of research,

knowledge transfer and extension/advisory services committed to the developments and application of new models of livestock and crop production that are less polluting, especially in terms of waste generation and disposal

- x) The threats and opportunities from global climate change that will increasingly influence agriculture and the rural environment, underline the crucial need to factor in this formidable challenge when developing new models of livestock and crop production systems, with immediate attention to forestry developments
- xi) The growing need to strike the appropriate balance between the price competitiveness of Europe's agriculture and food industries, and society's/consumers' concerns in relation to food safety, quality and food-health relationships, the environment, zoonoses, animal welfare, and also the developments in biotechnology and other new technologies, will be a major determinant of the future competitiveness and sustainability of Europe's agri-food industries and rural economies.

3. Competitiveness & Sustainability Prospects

Ongoing policy and other developments in Europe and beyond indicate that EU agri-food industries and the wider rural economies will, in the coming decades, be operating in a climate characterised by:

- i) Reduced price supports for agricultural products and declining real agricultural prices
- ii) More liberal world trade in agricultural products, with much reduced protection from global competition
- iii) A sustained focus on competitiveness, involving the scaling-up, rationalisation and intensification of agricultural production systems
- iv) Greater differentiation in agricultural production, resulting in specialised farming systems, with further decoupling of crops and livestock production
- v) Extensive livestock grazing systems will, in the more productive regions, be replaced by intensive industrial-scale systems, using improved genetics

and more balanced and efficient feeding systems, operated by well-trained managers

- vi) While cereal supply and demand will continue to increase, meat and dairy products will provide a growing share of the human diet, with the poultry sector expanding most rapidly
- vii) The concentration of the more intensified agricultural production and food processing industries in highly productive farming regions and the withdrawal of agriculture from marginal farming areas, will result in rural Europe being characterised by (a) *Intensive Farming Areas* where conflicts between competitiveness and sustainability may not easily be resolved; (b) *Extensive Farming Areas*, with predominately part-time farmers, engaged in extensive beef/sheep and crop production, including farm-forestry; and (c) *Marginal Farming Areas* where the withdrawal of agriculture will result in traditional rural landscapes being replaced by scrub encroachment and/or afforestation, with adverse consequences for the amenity and tourism value of important natural and cultural upland and wetland areas
- viii) There will be a sizeable decline in economic activity and population in many areas of marginal and possibly also extensive farming; coastal and other high amenity areas may experience significant growth; and interfacial areas between urban and rural areas will experience unprecedented economic and social pressures
- ix) With the relationship between agriculture and the environment out of balance in most countries, more effective implementation of environmental legislation and the development of more sustainable farming systems (Section 5.1.4) are required to reduce the conflict between intensive agricultural production and environmental protection. Also, new technologies, including biological control methods and precision farming techniques, will optimise the use of agro-chemicals and natural resources, including water and energy
- x) The rate of loss of wildlife habitats due to farming will decline, forests will be managed in a more sustainable way, but land-degradation will remain a serious problem
- xi) While greenhouse gas emissions from agriculture are expected to increase in Europe, the problem will be mitigated by reduced livestock numbers

- xii) Societal/political pressures to produce food that is more healthy; growing demand for health-promoting and safe food products, including diverse beverages; and major new markets developing for functional foods, including both probiotics and nutraceuticals
- xiii) Consumer preferences and rapidly changing lifestyles will lead to a much expanded market for convenience foods, combined with more extensive electronic home shopping
- xiv) There will be further concentration of retail purchasing and possibly more corporate alliances between food producers and manufacturers
- xv) Innovations in food production and processing may be accelerated by advances in biotechnology, genomics and other new technologies, especially in relation to human diet and food hygiene
- xvi) The requirement to become less dependent on non-renewable energy sources can be expected to provide new market opportunities for agriculture and forestry.

4. Multifunctional Agriculture

Following the fundamental reform of the Common Agricultural Policy (Luxembourg, 2003), the overall policy framework has shifted towards rural development, in particular the development of a multifunctional European agriculture. The concept of multifunctional agriculture recognises that, in addition to the production of commodities, agriculture encompasses other functions. These include the maintenance of rural landscapes, including the protection of the natural and cultural heritage; the enhancement of the safety, quality and health-promoting attributes of food; and supporting business opportunities for farmers and SMEs in tourism and outdoor recreational pursuits. The OECD perspective of multifunctionality is of an agriculture that *jointly* produces a range of commodity outputs (foods, fibres, energy crops etc.) and also a range of non-commodity outputs, including public goods, in particular environmental and social products and services. A fuller elaboration on multifunctionality, and the positive contribution of stable and prosperous rural communities to the social and economic sustainability of Europe's rural regions, is contained in the aforementioned Agriblue Foresight Blueprint.

The Declaration produced at the European Conference on Rural Development (Salzburg, 2003) states that “competitiveness of the farming sector must be a key aim of rural development,” as envisaged in the reformed Common Agricultural Policy. Equally, the Declaration recognises that “preserving the diversity of Europe’s country-side and encouraging the (public good) services provided by multifunctional agriculture is of ever growing importance” as evidenced by “the increasing importance European citizens attach to the preservation and enhancement of the rural environment.” The Declaration goes on to point out “that agriculture and forestry continue to play an essential role in shaping rural landscapes and in maintaining viable rural communities” and that “diversification both within and beyond the agricultural sector is indispensable in order to promote viable and sustainable rural communities.” Accordingly, the Declaration concludes that “there is a strong justification for public support for EU rural development policy to facilitate the ongoing process of agricultural restructuring, the sustainable development of rural regions and a balanced relationship between country-side and urban areas.”

As can be seen from the Salzburg Declaration, the rural development policy emanating from the 2003 reform of the Common Agricultural Policy can be envisaged as encompassing the following general aims:

- Development of an internationally competitive multifunctional agriculture, producing market-required food products and environmental goods and services
- Diversification of the economies of rural regions throughout the enlarged EU
- Protection and management of Europe’s rich heritage of rural landscapes and cultural diversity.

This tripartite set of competitiveness and sustainability aims reflects the overarching EU goals referred to in the Introduction (Section 1). Attainment of the appropriate balance between the seemingly conflicting demands of competitiveness and sustainability constitutes the single largest socio-economic challenge facing European agri-food industries and rural economies.

To address this multidimensional challenge, Europe's rural economies, including the agri-food and forestry sectors, need to be re-positioned in the knowledge economy. This will require closer alignment of the European Research and Innovation Area and national research programmes, with the development of a European multifunctional agriculture. As discussed in Section 5, it will require fundamental step changes in agri-food, rural development and environmental research agendas. In the context of increasing world trade, European countries will have to ensure their own economic, social and environmental sustainability, while at the same time becoming more responsive to global population and other developments, including future human welfare.

5. European Research Systems

Europe's agriculture and food industries have been built with the support of long-established national research, extension/ advisory and training services.

The multifunctional model of agriculture (Section 4) requires the development of knowledge-based agri-food industries and wider rural economies that have the technological and business capacities, expertise and entrepreneurial skills to produce and market innovative food products and environmental goods and services.

The existing research services, which are predominately provided by universities and state institutes, have provided invaluable support to the agriculture and food industries and rural economies, in some countries for a century or more. However, the cardinal question, which is strongly reinforced in the aforementioned Agriblue Foresight Blueprint, is – *What kind of knowledge and innovation infrastructure is required to support the future needs of rural economies, including the natural resource based sectors?*

As was repeatedly indicated by members of the Agriblue Foresight Blueprint Working Group, public sector governance issues (Section 5.1.5), including strategic directions, capacities, and organisational/ delivery structures, are widespread concerns. Also, the need for new funding mechanisms designed to ensure that the knowledge and innovation needs of rural economies are adequately provided for and in a timely

manner, is essential. Given the rapidly changing circumstances and increasingly competitive climate facing EU agri-food industries and the wider rural economies (Section 3), these issues need to be given urgent consideration. A number of important dimensions that need to be taken into account are outlined below.

5.1 Perspective of EU Agricultural Research

The longstanding need for an over-arching perspective of EU agricultural research, and its position within the European Research Area, has been recognised by, among others, the EU Standing Committee on Agricultural Research (SCAR). However, a number of attempts in the past decades to carry out such an exercise got “bogged down” in procedural and definitional issues. With EU enlargement, the sheer magnitude of the undertaking is unlikely to be commensurate with any potential benefits. Nonetheless, some appropriate form of stock-taking of the main thrusts of European agri-food research programmes is required to identify strategic gaps in existing knowledge-bases and how these could be used more effectively to inform policy and decision making, including regional planning. A policy-oriented research project funded under the EU Framework Programme would be an important step in addressing these issues.

5.1.1 Expenditure: It is not possible, with the information available, to indicate the current scale of expenditure on EU-25 agricultural research programmes, even if confined to publicly funded services. While agricultural research services have been curtailed in a number of member states, some, notably France, still have an extensive nationwide system. Among other countries, Germany, the UK, Spain, the Netherlands and Denmark also have comprehensive research programmes. If the scale of Ireland’s publicly funded agricultural research programme can be taken as a tentative indicator of the average for EU Member States, the total annual EU public expenditure (including the Framework Programme) could be equivalent to say 5% of the EU agricultural budget, which amounted to €48.9 billion in 2004. While this is obviously a ballpark guesstimate, it may provide some indication of the scale of public expenditure on agricultural research within the EU.

5.1.2 Institutional Capacity: The cardinal question is the capacity of the existing universities and state institute research services to adjust and re-orient their

programmes with the rapidity required to support the international competitiveness and sustainability of European agri-food industries and rural economies in the immediate years ahead. With some exceptions, the prognosis is doubtful, especially when compared to the prevailing position in the US and indeed elsewhere.

While EU and US agri-food industries produce, broadly speaking, similar bulk commodities, they are operating in markedly different circumstances, for instance in terms of scale of operation, geographical and climatic diversity, policy contexts and price support for agricultural products. Because of these differences, combined with the paucity of data in relation to relative research expenditures, any bench-marking of the agri-food research capacities of the EU compared to the US can go little further than the provision of broad overall perceptions, based on some knowledge of what is going on in important agri-food sectors and locations.

As further detailed below (Section 5.1.4), EU agri-food industries and rural economies require the support of Transition and High-Tech Research Programmes.

Transition Research Programme: In its totality, US research aimed at the further development of production systems in crops and livestock seems to be substantially stronger than is the current position in much of the EU, with the possible exception of some consumer/societal dimensions (Table 1). The main concern in relation to EU capacities is the serious depletion in recent decades of national research capabilities in the development of crop and livestock production systems, allied to the relatively low priority given to such research in previous EU Framework Programmes. A related issue is the quality of PhD training.

Because of BSC and other consumer/societal concerns, EU capacities in research on food safety, the environment and animal welfare are in some circumstances stronger than is the position in the US. Conversely, the US seems to have more comprehensive research programmes in rural sociology and agri-food policy analysis.

The opportunity exists to develop a European model of a knowledge-based multifunctional agriculture and integrated rural economies (Section 4). To achieve this, urgent priority needs to be given to rebuilding national capabilities (including the

research infrastructure) required for the development of new crop and livestock production systems that are internationally competitive and environmentally sustainable. Allied to this, concerted research programmes designed to support innovation in rural regions are urgently required. Otherwise, there is a serious threat that EU rural regions may become economically, socially and environmentally unsustainable in the immediate decade(s) ahead. Some indicative areas where EU research capabilities need to be strengthened are presented in Section 6.1.

High-Tech Research Programme: The current EU research capacities in agri-food biotechnology and other new technologies is, in general, many orders of magnitude weaker than in the US. While some EU countries have world-class high-tech agri-food research groups, EU research is generally characterised by fragmentation, lack of critical mass, discontinuity and little overall cohesion. To highlight the differences in scale between the US and EU research commitments, it is conceivable that the amount of high-tech agri-food research being undertaken in California may be greater than in any individual EU country.

Subject to the rapid development of the necessary scientific and technological capabilities, the opportunity exists for the EU to have agri-food industries that would be internationally competitive in the context of freer world trade in agricultural products, following the ongoing WTO negotiations. However, the investment in building the required high-tech research capabilities must be made now. Otherwise, EU agri-food industries and associated rural economies will be adversely affected by much greater international competition, arising especially from countries with rapidly developing agricultural economies, and where the biotechnology developments are being widely applied. Some indicative areas where immediate attention needs to be given in building EU research capabilities are presented in Section 6.2.

Table 1: Transition Research Programme

To shift the agri-food industries from a volume/output bias to a more consumer/society multifunctional strategic direction.

EU RELATIVE TO US	STRENGTHS	WEAKNESSES
<p>1/ - The research on the progress development of production systems is substantially stronger in the US than is the current overall position in much of the EU, with the possible exception of some consumer/societal dimensions (see 2)</p>	<p>2/ - The increased priority given by many EU countries in recent decades to consumer/societal concerns, including food safety, the environment and animal welfare</p>	<p>3/ - National capacities (including research infrastructure) required for the further development of crop and livestock production systems have been seriously depleted in recent decades</p> <ul style="list-style-type: none"> - Relatively low priority given to such research in previous Framework Programmes - Quality of PhD training
OPPORTUNITIES	ACTIONS – BUILD ON STRENGTHS	ACTIONS – ADDRESS WEAKNESSES
<p>4/ - Development of a European model of knowledge-based multifunctional agri-food industries and integrated rural economies</p> <ul style="list-style-type: none"> - Development of sustainable biofuels 	<p>5/ - Research-informed development and implementation of EU agri-food policies and directives</p> <ul style="list-style-type: none"> - Concerted EU research on food for health and on multidisciplinary rural catchment areas, spanning a range of agricultural and environmental situations 	<p>6/ - Concerted EU research programmes on sustainable agriculture, with particular regard to the development of new crop and livestock production systems that are internationally competitive and sustainable (see Section 6.1)</p> <ul style="list-style-type: none"> - Development of a new European system of PhD training
THREATS	ACTIONS – BUILD ON STRENGTHS	ACTIONS – ADDRESS WEAKNESSES
<p>7/ - Progressive erosion of EU international competitiveness in agricultural products</p> <ul style="list-style-type: none"> - EU rural regions that are economically, socially and environmentally unsustainable - Emerging climate changes 	<p>8/ - Increased priority in the EU Framework Programmes to research on sustainable agriculture and rural economies</p>	<p>9/ - Concerted EU research programmes on innovation in rural regions</p> <ul style="list-style-type: none"> - Concerted EU research programmes on the development of crop and livestock production systems that can cope with climate change (see Section 6.1)

Table 2: High-Tech Research Programme

To ensure the international competitiveness of the agri-food industries, especially in the context of freer world trade in agricultural production following the ongoing WTO negotiations.

EU RELATIVE TO US	STRENGTHS	WEAKNESSES
1/ - EU research in agri-food biotechnology is orders of magnitude weaker than the US	2/ - Some EU countries have world class research groups, but the overall EU position is much weaker than the US	3/ - Fragmentation - Lack of critical mass - Discontinuity - Little overall cohesion
OPPORTUNITIES	ACTIONS – BUILD ON STRENGTHS	ACTIONS – ADDRESS WEAKNESSES
4/ - Development of the scientific and technological capabilities required to support the international competitiveness of EU agri-food industries in the context of freer world trade in agricultural products	5/ - More extensive collaborative EU research on GM-related hazards post-release and on issues forming society’s attitudes to biotechnology and other emerging technologies	6/ - Substantially increased and sustained publicly funded research programmes on strategically important issues (see Section 6.2)
THREATS	ACTIONS – BUILD ON STRENGTHS	ACTIONS – ADDRESS WEAKNESSES
7/ - Much greater international competition, especially from countries with rapidly developing agricultural economies - Public concerns about perceived technological risks - Global climate change - EU-food security due to excessive dependence on imports	8/ - Greater convergence between EU Framework Programmes and the further development of the European model of multi-functional agriculture - Greater co-ordination of national and EU research programmes on climate change	9/ - Development of an EU Research Area in agri-food biotechnology, involving sustained public funding for strategic research undertaken by universities and state research institutes. This is essential in allaying public concerns with those rapidly developing technologies and reducing the impacts of climate change on European agriculture (see Section 6.2)

In the further development of European research programmes geared to meeting the competitive and sustainability needs of the agri-food industries and rural economies, the issues outlined below need to be taken into account.

5.1.3 *New Conceptual Framework:* The major policy developments, international drivers of change, multifunctionality and the competitiveness and sustainability prospects outlined in Sections 2, 3, & 4 point to the pressing need for a new conceptual framework or paradigm for agri-food research and the related areas of the environment and sustainable rural economies. In developing such a framework, three dimensions of cardinal importance are, the strategic context, knowledge transfer and research governance.

5.1.4 *Strategic Context:* Among the policy developments and other international drivers of change (Section 2), two are of fundamental importance in setting the strategic context for research in agri-food, environmental sustainability and the future viability of Europe's rural regions. These are the continuing reform of the Common Agricultural Policy and the ongoing WTO negotiations.

To confront these and other challenges (Sections 2, 3 & 4), a two-dimensional research strategy is required, involving

- *A Transition Research Programme* designed to support E-25 agri-food industries and rural economies in the shift from the production/output bias of the former Common Agricultural Policy, to the more consumer/society concerned multifunctional model, envisaged in the reformed policy (Luxembourg, 2003).
- *A High-Tech Research Programme* designed to ensure the international competitiveness of EU-25 agri-food industries and rural economies, in the context of freer world trade in agricultural production, following the ongoing WTO negotiations.

The two research programmes should be designed to support both the competitiveness and sustainability of EU agri-food industries and rural economies. However, the *Transition Research Programme* is envisaged as being somewhat more concerned with sustainability in the context of the transition to the reformed Common

Agricultural Policy. The *High-Tech Research Programme* is, on the other hand, more concerned with the longer-term international competitiveness of EU agri-food production systems and products, especially in a situation of freer world trade.

It should be noted that the two research programmes are not seen as separate discrete entities. They are a complementary continuum. Moreover, EU research capacity in both programme areas needs to be immediately strengthened and closely linked with the wider scientific knowledge system. The prime purpose of making the differentiation between the two programmes is to highlight the frequently overlooked need for concerted EU research geared to supporting the agri-food industries and rural economies *in the immediate years ahead*, in face of fundamental and continuing changes in the Common Agricultural Policy, declining financial supports for agriculture and growing competitiveness and sustainability challenges (Sections 2, 3 & 4).

To underline the crucial importance of the Transition Research Programme, it should be noted that there is an urgent need to develop new models of livestock and crop production systems for intensive, extensive and marginal farming areas (Section 3.vii). At the design stage in developing such new systems, the following parameters need to be built in from the outset:

- Farm profitability and international competitiveness are inherently important
- Costed environmental sustainability measures – otherwise environmental concerns with the new farming systems will continue to be “playing catch-up”, as is the prevailing position with the current systems
- Production of consistent quality raw materials required by internationally trading food processing companies and not for disposal through the EU Intervention System, as was the situation in previous decades
- The capacity to cope with emerging climate changes and growing demands on water and other natural resources

The Transition Research Programme may also be important in enabling countries to build the capability platform required to embark upon the High-Tech Research

Programme. The indicative portfolios for the Transition and High-Tech Research Programmes presented in Section 6 illustrate the importance of the proposed two-dimensional research strategy in the rapidly changing circumstances that the EU agri-food industries and rural economies must now adjust to and prosper in.

5.1.5 Knowledge Transfer: Within the R&D chain, ranging from conceptualisation of the research hypothesis or question to product and process innovations, knowledge transfer is all too often one of the weakest components.

With the single-minded pursuit of research excellence, the impression could be formed that knowledge transfer is expected to happen by a *process of osmosis*. This is reflected in the general disparity in the relatively small and sometimes decreasing proportion of national and EU science budgets allocated to knowledge transfer and innovation, as opposed to knowledge creation.

The transfer of knowledge to farmers and rural communities has been adversely affected in recent decades by the substantial depletion of public extension/advisory services in many European countries. Yet, with the daunting challenges and changing circumstances detailed in Sections 2, 3 & 4, these services were never more required. Indeed, some observers contend that the effective transfer and uptake of the existing reservoir of knowledge has become a more crucial determinant of the future competitiveness and sustainability of Europe's agri-food industries and rural economies than the generation of new research knowledge.

This proposition can of course be challenged. For instance, the Indicative Research Programmes outlined in Section 6 are required to support the future competitiveness and sustainability of Europe's agri-food and rural economies. Equally, however, it must be acknowledged that the sustained commitment of a sizeable proportion of national and EU science budgets to the systemic transfer of existing knowledge would be likely to result in more innovative developments than the current preoccupation with investing preferentially in the front-end of the R&D chain, especially in fundamental or curiosity-driven research.

Weak technological absorptive capacity is an inherent feature of most SMEs and micro-companies, including farms and rural businesses. Thus, in addition to the two-dimensional research strategy (Sections 5.1.4 & 6), urgent priority needs to be given to improving the efficiency of knowledge transfer and its uptake by potential adopters in agriculture and rural regions. To raise the impact of agri-food research undertaken within Member States and the European Research area, two key elements of a rural knowledge infrastructure are required. These are extension/advisory services, and training programmes. The funding provided for the provision of farm advisory services under the reformed Common Agricultural Policy (Luxembourg, 2003) is an important initiative. Experience shows that the cost-effectiveness and impact of extension/ advisory services are improved where an appropriate portion of the funding is provided by client farmers who are committed to developing their businesses.

Training programmes also constitute an effective conduit for innovative knowledge diffusion to farmers and other rural dwellers. In this regard, the feasibility of developing EU accredited training programmes for prospective farmers and rural entrepreneurs may merit consideration. In addition to providing a fuller undertaking of the major policy and other developments that are shaping European agriculture and rural economies, and the knowledge necessary to address the major challenges facing the sectors, EU accredited training programmes would facilitate the mobility of farmers and others between Europe's rural regions.

5.1.6 Research Governance: Research governance, in terms of strategic capacity, institutional structures, direction and programme management, is fundamental to ensuring

- that resources are deployed on properly informed real research needs of competitive and sustainable European agri-food industries and rural economies
- the direction and systemic management of the inter-disciplinary and inter-institutional research teams, with the critical mass and range of expertise necessary to develop the knowledge base required to address the complex competitiveness and sustainability issues outlined in Section 2, 3 & 4

- raising the impact of agri-food research within Member States and the European Research Area
- delivering an adequate return on the sizeable expenditures involved
- to improving the efficiency of knowledge transfer (Section 5.1.5)

The actual research undertaken in Europe on agri-food and rural economies is, with some exceptions, generally well conducted. However, questions are repeatedly raised regarding the relevance of the research and, increasingly, the contribution of the knowledge generated to raising the competitiveness and sustainability of the agri-food industries and rural economies.

To address these important and pressing concerns, more effective research governance, including new institutional and financing arrangements, is urgently required, as further underlined below (Sections 5.2, 5.3 & 5.4). In particular, the involvement of funders, from both the public and private sectors, as well as NGOs, is essential in improving research governance. This is important in relation to the Transition Research Programme, and especially the High-Tech Research Programme (Section 6).

5.2 Environmental Research

The complex array of interactive issues involved in reconciling the seemingly conflicting demands of environmental development and environmental management need to be better understood in order to be managed effectively.

A number of European countries have research teams with established international track records in environmental research, as well as much of the basic scientific infrastructure. However, the rural environmental research capacity in many countries is all too often characterised by fragmentation, narrow focus, lack of critical mass, discontinuity and little overall cohesion. The pockets of high-quality research groups do not have the capacity individually to effectively address rural environmental problems of major importance. This is especially true of many traditional agricultural research organisations. Also, major gaps and weaknesses exist in such vital capabilities as environmental economics, modelling, hydrology, baseline data, and

monitoring protocols, some of which may be more readily provided by established environmental research centres.

To strike the optimum balance between the economic dictates of internationally competitive agri-food industries allied to sustainable rural economies and the protection of Europe's rich heritage of natural and cultural resources, a more concerted European rural environment research programme would be beneficial. A well-focused research programme would act as a strong integrating force in drawing the ongoing environmental research conducted by EU member states into a coherent European Programme with the focus and capacity to address major environmental issues.

The primary function of the European Programme would be to provide a research-based understanding of the fundamental chemical, biological, pedological, engineering and socio-economic pressures required to achieve the optimum balance between the economic dictates of competitive agri-food industries and rural economies, including the agri-food sectors, and protection of the Europe's rural landscapes (Section 2.x). The daunting challenge involved in striking the optimum balance points to the concept of envisaging the environment as a virtual economic entity, within which a dynamic range of competing developmental, environmental, and social pressures have to be systemically accommodated, without the demands of one sector impacting unduly on others.

A coordinated EU Programme would provide a concerted European approach to research on the following important dimensions of the rural environment, (see Sections 6.1 & 6.2)

- *Water, Air and Soil Resources*

To develop the enhanced scientific and engineering knowledge required to protect water, air and soil quality in a cost-effective manner, and improve the use efficiency of these vital environmental resources

- *Biodiversity*

To develop the scientific understanding of ecological processes that is necessary for the effective management, conservation and economic utilisation of biodiversity and the sustainability of rural ecosystems

- *Forestry*

To improve the scientific and technological knowledge required to maximise the ecological, social and economic contributions of sustainably managed forests and afforestation developments

- *Rural Landscape*

To provide the research capability to guide policy formation in relation to the protection of Europe's rural landscapes including wetlands, uplands and coastal areas, and their rich archaeological heritage, and the development of sustainable rural settlement strategies

- *Environment Economics/Legislation*

To quantify the costs and benefits of environmental policies, EU Directives, legislation/regulations and financial incentives, and to establish the value of public goods associated with agriculture, forestry and fisheries and the importance that needs to be attached to their protection

- *Ecology & High-Tech Developments* (See Section 6.2.iii)

5.3 Competitive Sustainable Rural Economies

The complex dynamic between the domains of agriculture, food, health, the environment, land use, society and the economy are comprehensively dealt with in the aforementioned Agriblue Foresight Blueprint. Having pointed out that what is required is not more academic research, the Blueprint states that a “regionally based demand-driven approach to research and innovation needs a totally different funding approach from that applied to universities and national research institutes. University research is guided by a focus on global excellence designed to attract the best brains to a curiosity-driven research agenda and national institutes are driven by national needs. For purely practical reasons, neither can respond to the differentiated needs of each region. Knowledge regions are regions in which the knowledge-needs of all producers are met and not just those of large, world class actors, capable of independent research themselves.”

It goes on to conclude, as previously indicated (Section 5.1.6), that one of the most important issues that urgently require attention is “what kind of knowledge and innovation infrastructure can best serve the needs of rural economies.” The single-minded pursuit of global excellence, which is beginning to characterise much fundamental or academic research in Europe, needs to be complemented by demand-driven research and innovation systems.

The central role of knowledge in driving national and regional innovation and economies points to the need for the development of new models for the organisational structure and delivery of research and innovation. To meet the specific context-dependent needs of rural regions, an analogue of the US Land Grant Colleges may be appropriate. These colleges were established with a strong extension role in delivering new knowledge to potential adopters in rural areas. Such an extension model would position the higher education organisations to act more directly as intermediaries in developing clusters of indigenous business. In particular, it would provide a structured system for meeting not just the research requirements of rural regions and indigenous businesses, but also their education and training needs (Section 5.1.5).

A widespread anomaly in relation to these repeatedly defined needs is, as already indicated, the persistent discrepancies in the relatively small, and often decreasing, proportions of national and EU science budgets allocated to knowledge diffusion as opposed to knowledge creation.

An innovation-driven approach to research needs a radically different funding system from that conventionally applied to higher education institutes. To raise the capacity of Europe’s agri-food industries and rural regions to generate, absorb and integrate research and technological innovations and transfer them into economic growth, the fundamental requirement is a dedicated strategic funding system. This needs to be designed so as:

- To capitalise on comparative advantages, by mobilising all the resources available, towards the attainment of context-dependent and demonstrably attainable goals; and also,
- To take advantage of best practices and models available in relation to the governance and delivery of research, technology implementation and innovation.

In designing a demand-driven research and innovation system, an interesting model is the New Zealand system of Crown Research Institutes, dedicated to the commercialisation of research, customer focus and management of intellectual property rights.

5.4 Policy-Oriented Research in Agri-Food, the Environment and Rural Economies

The policy research calls in EU Framework Programmes are an important development. However, the continued disconnectivity between policy makers, policy researchers and those engaged in scientific research is a serious concern. All too frequently, research proposals formulated by scientific researchers highlight the implications of the research for EU and national policies, but show an inadequate appreciation of the complex underlying issues involved. Also, what are purported to be policy research projects are frequently undertaken without any real involvement with those engaged in policy development and its implementation. There is a pressing need for closer interactions between policy makers and scientific research. While it may seem excessively restrictive, with few exceptions, policy-oriented research should not be embarked upon without adequate consultation with those familiar with the policy/policies concerned. Indeed, an appropriate level of involvement in the actual research by those responsible for the development and/or implementation of the policy issues would be beneficial in ensuring the relevance of the research and implementation of the outcomes.

The engagement in foresight initiatives by both policy makers and researchers has been useful in bringing about a better understanding between the two sides in relation to what research can realistically achieve and in articulating research investment

needs. Some specific aspects of policy-oriented research that merit consideration are outlined below (Section 6.1.vii).

6. Knowledge-Competitiveness & Sustainability

As an industry inherently based on the exploitation of natural resources, the overarching EU goals of competitiveness and sustainability referred to in the Introduction (Section 1) present virtually unique challenges for agriculture and forestry, and also the marine sector. In the short to medium term, many environmental, animal welfare and food safety measures may operate as competitive constraints on EU agri-food industries. Currently, consumers are not, in general, prepared to pay more for foods produced in accordance with strict environmental and animal welfare requirements. However, countries that achieve the optimum balance between the economic dictates of profitability in agriculture and at the same time address environmental and consumer concerns (Section 3) will have internationally competitive agri-food industries in the coming decades. *Knowledge is the key to attaining this crucial balance.*

This brings into sharp focus the particular relevance to the agri-food industries of the Lisbon Strategy to make the EU the most competitive and dynamic knowledge-based economy. It also highlights the importance of ensuring, within the context of ongoing ERANET actions, closer alignment of national research programmes and the EU Framework Programmes with the development of multifunctional models of EU agriculture. Further to this, the major challenge facing public institutions engaged in agri-food research is to provide the integrated knowledge base in both the technical and social sciences to achieve the difficult balance between the competitiveness of the agri-food industry and society's growing concerns in relation to the industrialisation of food production, which, as indicated in Section 3, is expected to become more prevalent, especially in the intensive farming regions of Europe. The need to get the balance right between competitiveness and sustainability underlines the imperative need for continued investment in university research programmes and state institutions concerned with agri-food research and the effective transfer of the knowledge generated to prospective and existing farmers and food processors.

For these public institutions to position themselves to fulfil this pivotal and demanding role, a two-dimensional research strategy is required, as already outlined (Section 5.1.4). Some important research issues pertaining to the Transition and High-Tech Research Programmes are given in the *Indicative Research Portfolios* presented below. In this regard, two points should be noted. *Firstly*, the set of issues listed is not intended to be exhaustive, but rather to illustrate the scope and different thrusts of the two research programmes. *Secondly*, and more importantly, the purpose is to highlight the need for a Transition Research Programme. In the immediate years ahead, the competitiveness and sustainability dimensions of the EU agri-food industries and rural economies will not be met to any sizeable degree by advances in the new technologies. As previously stated (Section 5.1.4), the need for a Transition Research Agenda for the EU agri-food industries is frequently underestimated in developing research policies. In the domains of research policy, industry development and social concerns, this issue merits early consideration by EU countries. It is of paramount importance to new member states, where a high proportion of the population will continue to be dependent on jobs in agriculture and food processing in the coming years and where the enterprises are often operating at low levels of productivity.

6.1 Transition Research Programme – Indicative Portfolio

The Food Supply Chain is changing constantly, as technological innovations in farm production, food processing, storage and delivery systems evolve, and processors and retailers respond to consumer demands and expectations, and to economic, social and cultural circumstances. To provide the agri-food industries and rural regions with the knowledge base required to respond to these dynamic, multifaceted changes, some important research issues that need to be addressed are set out below:

- i) *Consumer Demands*: Fuller understanding of the concerns and circumstances that are forming consumer attitudes and choices, and of how these can best be reflected in farm production strategies, is required; also, priority needs to be given to the fuller development of models of consumer preferences, to guide research, product development and innovation
- ii) *Food for Health*: A concerted European Research Programme on the development of food production and product strategies for the nutritional

enhancement of foods, would create science-based opportunities for the agriculture and food industries. Elucidation of the complex interactions between food components and human health is required to alleviate, through food choice, population ailments such as obesity, cancer, diabetes, CHD, etc. To improve the well-being and health quality of society through the wider availability of science-based health-promoting foods, priority needs to be given to an EU collaborative interdisciplinary research programme on the following aspects of diet-health relationships and the development of effective interventions, including functional foods:

- Understanding of the mechanisms of the action of physiologically-active food components and bacteria
 - Food structure and sensory properties that underpin the development of foods for personalised nutrition
 - Discovery of new physiologically-active components of natural origin and bacteria with potential for use in functional and probiotic foods
 - Development of bioassays and biomarkers related to the clinical efficacy of bioactive food components
 - The inter-relationship of gut flora and human health as related to functional food innovation
 - Genomic research aimed at discovery of the molecular basis of the health value of food produce, with particular regard to milk, fruits and vegetables
- iii) *New Models of Production Systems*: The development of new and improved production systems designed (see Section 5.1.4) (a) to optimise nutritional and genotype interactions in crops and livestock, so as to produce consistent quality raw materials for the food processing industry, in a cost-effective manner, while taking into account changing work and lifestyle issues; and the need to improve the use efficiency and protection of natural resources, including soils, water, air, biodiversity and space; (b) to produce high quality horticultural produce, especially vegetables and fruits, both at commercial and familial scales, having regard to increasing urban-peri-urban-rural interactions; and (c) to provide regionally attuned production systems, including small scale enterprises, suited to local

agronomical, ecological and climatic conditions that provide opportunities for building new food chains, based on high value regional products and organic food produce

- iv) *Rural Environment* (See Sections 5.2 & 6.2.iii): Research on the environment has largely concentrated on its individual components, such as water, soil and biodiversity. The mechanisms by which these interact in the complex, real human/ecosystem are poorly understood. Immediate priority needs to be given to research on the interactions of different environmental and land-use components and the implications for policy makers. To provide the data sets required for the use efficiency of natural resources and for an early understanding of the consequences for the rural environment of expected changes in land use (agriculture, forestry, infrastructure etc.), multidisciplinary research catchments need to be established, spanning a range of agricultural, forestry, and climatic situations across Europe, and taking into account some related national programmes already underway (Ecology & High-Tech Research Programme, see Section 6.2.iii)
- v) *Sustainable Rural Economies*: To facilitate innovation in rural areas, a better understanding is crucial in relation to the institutional arrangements (a) required to generate economic activities in rural areas, including the role of government (national and regional), the engagement of influential stockholders (public and private sectors) in regional networks and the preconditions and opportunities for effective clustering of SMEs with multinational companies, including the differentiated positions and strategies of these companies; and (b) effective provision of social and environmental services
- vi) *Regulatory Framework*: Cost-effective farming strategies are required for the incorporation into livestock and crop production systems of EU directives and national legislation, in relation to safety, health and trade
- vii) *Policy Developments*: some aspects of research in agri-food economics/policy that are important from a competitiveness and trade policy perspective are outlined below:
 - The further development of quantitative sectoral and farm models to project the impact on European agri-food industries of reduced price

supports (CAP reform); liberalisation of trade and globalisation of markets (WTO outcome), and environmental constraints and quantification of their impacts, especially on the economic, social and environmental sustainability of rural regions

- Establishment of the consequences for EU livestock, crops, horticulture and forestry sectors of increased global sourcing, allied to new processing and transport technologies
- Evaluation of public research programmes, in terms of their impacts, including the justification of research expenditures; and improving research efficiency and the incorporation of research findings into policy developments.

6.2 High-Tech Research Programme – Indicative Portfolio

Sustained investment in biotechnology and other advances in the life sciences is vital to the longer-term competitiveness of the EU agri-food industries. Given the magnitude of investment in the development of these technologies, notably in the US, and also Australia, New Zealand, Brazil, India and China, international competitiveness is the cardinal concern. There are two other central reasons why EU countries need independent agri-food biotechnology research programmes involving high-quality academic and state research institutes. These are:

- To evaluate and adapt to their own industry needs international advances in biotechnology. Otherwise they will be “*importing biotechnology in the dark.*”
- To provide society with science-based confidence, countries must have trustworthy, credible and impartial research information in relation to environmental, food safety and other perceived risks associated with developments in biotechnology. If this is not done, and done immediately, the fate which befell food irradiation is likely to be repeated with agri-food biotechnology.

Those engaged in biotechnology try to allay public concerns about the perceived risks. However, the actual issue that needs to be addressed is not the risks but the uncertainties. The underlying concern of society is the uncertainties associated with

biotechnology and other rapidly changing technologies. Knowledge provided by publicly funded research is the key to reducing these uncertainties. This brings into sharp focus the central role which universities and state research institutes can play in biotechnology. The uncertainties would be most effectively addressed by sustained public funding of strategic research programmes undertaken by universities and state institutes. This role cannot be provided by private companies or by research dependent on funding by such companies. However, public institutions undertaking this essential task may require new governance structures (Section 5.1.6). With a view to reaching a balanced, knowledge-based position in relation to biotechnology, and also giving the conflicting sides of the biotechnology debate on ownership of the outcomes of the research, there may be merit in the research institutions establishing consortia to advise on the overall balance of their research programmes. The consortia should include the following stakeholders: management of the research institution; scientists with the relevant international standing; scientists with knowledge of society/consumer concerns (environment, food safety, etc.); senior officials from the funding government ministry or agency and representatives of both the biotechnology industry (who should not be involved in providing *core* funding); and consumer organisations.

With a view to developing crop and livestock production systems that are competitive and sustainable, some important issues that need to be addressed by publicly funded research programmes are outlined below:

- i) *Plant Sciences*: to improve the sustainable production, yield, co-existence, quality, nutritive value, functionality, storage stability and processability of important EU food and non-food crops (cereals, legumes, fruits and vegetables, forage crops, oil-producers, important wood-producing trees, etc.) and their genetic resources, priority areas in plant research include genomics, biotechnology, biodiversity, non-food uses and the impacts of climate change, with particular regard to the following:
 - Molecular understanding of plant susceptibility and resistance to pests, diseases and environmental stress; expected climate changes may increase the diversity and spread of pathogens and impose additional heat, cold and drought stresses on plants

- Plant metabolism aimed at developing plants containing higher levels of important macro- and micro-nutrients (essential fatty acids, oils, vitamins, amino acids, antioxidants, fibres, etc.) and reduced allergen levels; and a better understanding of plant carbohydrate metabolism, especially control of source-sink relationships
 - Development of crops that require less fertiliser-usage and other agro-chemicals, and that also require less water resources, based on a fuller understanding of factors regulating nitrate and phosphate utilisation, water-use efficiency and impact on natural resources
 - Development of breeding strategies for the efficient introduction of desired traits into high-yielding crops, using the vast potential available in genetic resource collections
 - Non-food uses of crops, including bio-fuel crops and transgenic crops producing protein products or novel metabolites for the pharmaceutical and chemical industries
 - Understanding of afforestation and the provision of planning assistance in the selection of sustainable genetic resources and disease management issues tailored to local conditions
 - Understanding of soil microbiological communities and their role in plant growth, the retention of carbon and the contribution of soils to gaseous emissions
- ii) *Animal Sciences*: To improve the efficiency and sustainability of livestock production, in terms of food quality and safety, the environment, zoonoses and animal welfare concerns, priority should be given to the following:
- The identification of genes that control immuno-resistance in livestock, including pigs and poultry, leading to improved disease prevention strategies, for such persistent and costly diseases as mastitis, John's disease, parasitic gastroenteritis, Avian influenza, Newcastle's disease, coccidiosis, classical swine fever, etc.
 - The development of improved livestock breeding and nutritional strategies, including reduction of the growing infertility problem in modern dairy cows

- A fuller understanding of the functioning of the rumen ecosystem is required to underpin the development of improved animal nutrition strategies and technologies for the production of health-enhancing milk and meat, and the reduction of gaseous emissions, especially methane production by cattle
 - Improving nutrition and welfare in intensive pig production and reducing pollution and food-borne diseases
- iii) *Environment* (See Sections 5.2 & 6.1.iv): Ecology, and particularly niche and life-history studies of crops, is pivotal in avoiding GM-related hazards post-release. With ecology an essential issue in the GM development process, research priorities should include investigations of:
- The differential understanding of urban and rural societies in relation to biotechnology and other emerging technologies (Section 6.1.1) and of their potential in agriculture and food production
 - The direct impact of GM crops on cropland ecosystems (including pest resistance), relative to conventional and organic crop production systems
 - The persistence of transgenic DNA in wild plant populations, following GM crop hybridisation event(s) and the ecological effects of changes in individual plant fitness, arising from the presence of transgenic DNA
 - The use of ecology, human food chain and livestock knowledge to maximise the potential benefits and minimise release-associated risks
- iv) *Diagnostics*: Development of new diagnostic tests for crops and animal diseases, including antibody-based diagnostic chips
- v) *Pharmaceuticals*: Development of vaccines for livestock diseases and pathogens, with particular regard to ensuring that inoculated natural infections can be distinguished.

7. Contributors to the Report

In addition to making important contributions to the preparation and finalisation of the report, Prof. Dr. F. Werrij (Secretary General of EURAGRI) collated responses from the EURAGRI network and the Committee on Research Cooperation of ISHS. He

also provided extensive comments received from the UK Department for the Environment, Food & Rural Affairs, following consultation with the Biotechnology and Biological Sciences Research Council, the Food Standards Agency, the Scottish Executive Environment and Rural Affairs Department and the Welsh Assembly Government.

In addition to a comprehensive submission received from Prof. Oene Oenema, the report was also informed by submissions and/or exchanges of views with the following: M. Boland, M. Bruen, J. Burke, P. Crehan, L. Donnelly, F. Doohan, M. Downes, A. Evans, T. Kavanagh, G. Keenan, M. Klaas, W. Parker, G. Purvis, J. Mannion, D. McConnell, C. Meade, M. Rath, B. Riordan, J. Roche, C. Spillane and M. Usher.

The report draws extensively on the author's background in scientific research, science policy, foresight initiative, both EU and national, and the strategic direction and management of national research, extension/advisory and education/training services in agriculture, animal health, food procession and the environment.

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