agriXchange
network for data exchange in agriculture

Draft of SRA
'Common Basis for policy making for introduction of innovative approaches on data exchange in agri-food industry'

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About the agriXchange project

agriXchange is a EU-funded project and it is a coordination and support action to setup a network for developing a system for common data exchange in the agricultural sector.

Project summary

Within the knowledge-based bio-economy, information sharing is an important issue. In agri-food business, this is a complex issue because many aspects and dimensions play a role. An installed base of information systems lack standardization, which hampers efficient exchange of information. This leads to inefficient business processes and hampers adoption of new knowledge and technology. Especially, the exchange of information at whole chain or network level is poorly organized. Although arable and livestock farming have their own specific needs, there are many similarities in the need for an integrated approach. Spatial data increasingly plays an important role in agriculture.
The overall objective of this project is to coordinate and support the setting up of sustainable network for developing a system for common data exchange in agriculture. This will be achieved by:

- establishing a platform on data exchange in agriculture in the EU;
- developing a reference framework for interoperability of data exchange;
- identifying the main challenges for harmonizing data exchange.

First, an in-depth analysis and investigation of the state-of-the art in EU member states will be carried out. A platform is built up that facilitates communication and collaborative working groups, that work on several, representative use cases, guided by an integrative reference framework. The framework consists of a sound architecture and infrastructure based on a business process modelling approach integrating existing standards and services. The development is done in close interaction with relevant stakeholders through the platform and international workshops. The results converge into a strategic research agenda that contains a roadmap for future developments.

Project consortium:

- Wageningen University & Research Center (LEI, LSR, Alterra) - The Netherlands
- Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) - Germany
- MTT Agrifood Research - Finland
- Wireless Info (WRLS) - Czech Republic
- Institut de l'Elevage (ELEV) - France
- Institut de Recerca i Tecnologia Agroalimentàries (IRTA) - Spain
- Teagasc - Ireland
- Universität Rostock -Germany
- Forschungsinstitut für Biologischen Landbau (FIBL) - Switzerland
- Altavia - Italy
- Poznan University of Life Sciences (PULS) - Poland
- ACTA Informatique - France
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Abbreviations

CAP	Common agricultural policy
DG	INFSO Directorate-General of the European Commission
DG	REGIO Directorate General for Regional Policy
Digital Agenda	A Digital Agenda for Europe
eRural IP	eRural Integrated Project
FP7	Seventh Framework Programme
GIS	Geographic information system
LEADER	European Community Initiative for assisting rural communities in improving the quality of life and economic prosperity in their local area
PR	Public relations
IPR	Intellectual Property Rights
RT&D	Research and Technology Development
RTD	Research and Technology Development
SMEs	Small and medium-sized enterprises
SRA	Strategic Research Agenda
WLAN	Wireless local area network
WIMAX	Worldwide Interoperability for Microwave Access
WTO	World Trade Organization
XML	Extensible Markup Language
i2010	i2010 - A European Information Society for growth and employment

Executive Summary

The agriXchange Strategic Research Agenda (SRA) goes beyond the general scope of the agriXchange initiative. It is focused not only on standardisation but also on the definition of research priorities for agrifood sector. The document is divided into five parts.

First, the introduction defines the background and scope, main problems, objectives and approach and outline for the rest of the document.

The second part gives an overview of previous activities. We analysed only those projects and documents that were focused in some way on a vision of future ICT for agri-food or eventually ICT for rural development. The analyses conclude that the progress in the deployment of infrastructure in Europe was very fast and changes from one year to the other were visible. In principle, anybody in Europe has possibilities of access to broadband, but the uptake of new solutions into practice and also research in agri-food and rural applications is slower than the deployment of infrastructure. In many cases application priorities are the same as 10 years ago. The big problem is the information exchange and interoperability. There are mentioned two reasons causing these problems - social aspects and local focus of agriculture production.

As a conclusion from the overview we can consider that it is necessary to support:

- The uptake of new technologies in primary production.
- A long term suitability of research and support for long time vision for RTD development in the agri-food sector.
- Better implementation of RTD results into practice.
- A strong professional organisation for the ICT agri-food sector, which will unify different efforts of different research and development groups, but which will also be able to protect interests of communities. The candidate for such an organisation could be EFITA, but it will be necessary to change the organisation structure of it.

Chapter three is focused on future challenges of ICT for rural communities, research trends and standardisation. The following challenges are defined for next period:

1. To include ICT and knowledge management for agri-food and rural communities generally as a vital part of the ICT policies and initiatives.
2. To find a balance between food safety and security, energy production and environmental production.
3. To support better transfer of RTD results and innovation into everyday life of farmers, food industry and other rural communities.
4. To accelerate bottom up activities as a driver for local and regional development.
5. Making rural regions as an attractive place to live, invest and work, promoting knowledge and innovation for growth and creating more and better jobs.
6. To build a new ICT model for sharing and use of knowledge in rural regions.

The ICT vision is mainly focused on the future internet. The following functions were recognised based on SmartAgrifood Analysis:

- The Internet is not limited to self-standing PCs; it will support direct communication between the machines, equipment, sensors, mobile phones, household refrigerators etc.
- There is a mobile equipment as data collector, data viewer (display) and information transmitter.
- Quick and real-time exchange of large amount of data/video/3D information is possible.

- Content based browsing - intelligent distribution and caching of content - each piece of information and each object gets an individual ID code. We need to specify properly what we want to know without knowing where to find it.
- Services of customized information - automatic integration of information on demand.
- It is possible to positioning with higher accuracy for exact identification of objects, and controlling of the (agricultural) machines and equipment.
- Cloud computing - it is able to handle tasks requiring high data processing and computing capacity. Users do not need to have their own infrastructure; it is available and accessible through the Internet at low cost and when necessary. Interworking is possible between local sub-systems and global system (cloud).
- Higher privacy which guarantees the protection of personal data.
- Global data warehousing and management capability is available (application for diseases, pesticides, fertilizers, foreign body, reference samples, etc.).
- Ability to monitor meeting a set technical requirements and initiate automatic corrective actions and/or alarming system operators.

The standardisation vision is based on two pillars:

- the structure of the framework model serves information sharing and harmonization development of the data exchange, and
- the implementation of the practical model tool (aXTool) in the agriXchange platform have to be user-friendly.

Fourth part is focused on defining SRA. Strategic topics are defined for application areas and for ICT development. Currently, we recognise the following priorities for research domain for Agriculture, Food, Rural Development and Environment:

- Collaborative environments and trusted sharing of knowledge and supporting innovations in agri-food and rural areas, especially supporting food quality and security.
- ICT applications for the complete traceability of production, products and services throughout a networked value chain including logistics.
- New generation of applications supporting better and more effective management of agriculture production and decision making in agriculture.
- ICT applications supporting the management of natural resources.
- ICT applications supporting agri-food logistic – the focus has to be on the transportation and food distribution, sharing online monitoring information from trucks during the transport of cargo, a flexible solution for on-demand dock reservation and an integrated freight and fleet management. In general, all the selected applications have the same practical benefits as cost reduction, better coordination and better information for decision making, and the proactive control of processes leading to increasing efficiency and effectiveness.
- ICT application supporting rural development and local businesses
- ICT application for education and awareness.
- ICT applications reducing administrative burdens in rural areas.

The development of knowledge-based systems for the farming sector has to be supported by ICT focused on:

- Future Internet and Internet of things including sensor technology, cloud computing and machine to machine communication.
- Service Oriented Architecture.
- Methods of knowledge management.
- Semantic models, multilingualism, vocabularies and automatic translation.

- Management and accessibility of geospatial information.
- Open Source development.
- New modelling.
- The power of social networks and social media.

Fifth part recommends how to continue in the future activities of agriXchange under umbrella of EFITA after the end of the financing period of agriXchange.

1 Introduction

1.1 Background and scope

The objective of this report is to provide a Strategic Research Agenda (SRA) which reflects the business demands for utilisation of ICT and exchange of agriculture information supported by current standardization, but also by future research in ICT for agri-food industry. It reflects the needs of the agriculture business. The focus of the SRA is on identifying major ICT challenges related to the utilization of ICT and information standards in agriculture and agri-food industry sector. The agenda defines not only the necessary ICT standards, but also in broader view the Research and Technology Development (RTD) areas which will be selected as key priorities in order to achieve the challenges identified. The wide deployment of knowledge management, which will include ICT technologies, exchange of information and utilization of ICT standards specifically oriented to the agri-food industry, will support the transformation of agriculture production into competitive and dynamic knowledge-based economy as well as facilitating the participation and ultimately the complete integration of the EU agriculture production into the Knowledge Society. The SRA is mainly focused on the KBBE and ICT programmes within the FP7, but it is based on activities on regional and cross-regional level as well as within other EU programmes and initiatives. It is critical to follow the main trends, but also cooperation with the main industry and ICT players involved. The definition of the SRA required a deep knowledge of previous activities, state of the art in agri-food ICT area, but also consultations with representatives from industry, governments, agencies, operators, and agri-food authorities and stakeholders involved in rural development in all Member States. The discussions with stakeholders during events such as the GeoFARMatics conference in Cologne or the EFITA congress in Prague played an important role. Currently, the first version of the SRA document is presenting the draft strategic lines that, after validation (mainly planned for the Smart Agrimatics conference), will support all domain stakeholders in the process of implementing a number of specific measures to achieve the stated objectives.

1.2 Problem

The agriculture sector is a unique sector due to its strategic importance for both European citizens (consumers) and European economy (regional and global) which, ideally, should make the whole sector a network of interacting organizations. Rural areas are of particular importance with respect to the agri-food sector and should be specifically addressed within this scope. There is an increasing tension that has not been experienced in any other sector between the requirements to assure full safety and keep costs under control. also It is necessary to assure the long-term strategic interests of Europe and worldwide [18]. To solve the problems of future farming, we need to develop new generation of knowledge management, which will help the agri-food sector to adopt in a changing world. The objective of future knowledge management is to help to agri-food sector to be competitive in the market in the sense of required products, quality and amount, to be able react on changes in the world market, changes in subsidies systems, requirements about environment protection, but also to be able to react for example on increasing costs of inputs or on climate changes. It is important to produce with long term sustainability of farm a protected soil as a main mean of farming production. The future knowledge management systems have to support not only direct profitability of agri-food sector or environment protection, but also activities of individuals and groups, allowing

effective collaboration among groups in agri-food industry and consumers and wider communities, especially in rural domain. Having these considerations in mind, the proposed vision lays the foundation for meeting ambitious but achievable operational objectives that in the long run will definitively contribute to fulfill identified needs. The knowledge management represents the ongoing relationship between people, processes and technology systems involved in designing, capturing and implementing the intellectual infrastructure of an organization. It encompasses the necessary changes in management attitudes, organizational behavior and policy. Knowledge management should create a value to the customer and turn profit to the firm. It is clear from the definition that knowledge management goes one step further from the simple concept of information systems and entails other two factors, people and processes [32]. This will require better exchange of information, but also adoption of new scientific and research results into agri-food sector.

1.3 Objectives

The first objective of the SRA is to build a vision for future scientific and research priorities, which will help to build the new future knowledge management. The objectives of this report are broader than pure focus on future standardisation of information sharing and exchange. The vision includes future challenges for ICT for agri-food sector, but also the definition of priorities for future research.
The second objective is to recommend a way for the long term sustainability of agriXchange initiative.

1.4 Approach and outline

The SRA is not built from scratch. There are two main sources of ideas that are used and extended in the agriXchange SRA. The first source are the results of previous activities. There were many activities trying to define the future vision or the SRA. In many cases the project results disappeared together with the project itself. The first part of our work was a deep analysis of previous work and to see what was done, what was already overcome and what is valid till now.
The second information source were the results from WP2, WP3 and WP4 of agriXchange. The analyses are used as an input and recommendation for the SRA. As it was already stressed, the SRA is not only focusing on the standardisation process but also on defining priorities for the future research.
A part of the recommendation is also a suggestion for the long term sustainability of the agriXchange initiative. The work is divided into fourth parts:

- The first part analyses previous projects and results of other WPs of agriXchange.
- The second part is focused on current ICT trends in agri-food sector and on defining future challenges.
- The third part is focused on defining future research priorities.
- The fourth part is focused on agriXchange long term sustainability.

2 Overview of past activities

ICT for agriculture, food, environment and rural development is not a new issue. There were many activities and initiatives during the last years. New research projects are very often starting from scratch without taking into account results from previous activities. Therefore, we decided to include this chapter to show some project results performed mainly during the first decade of the 21st century. We expect that this chapter can provide a good overview how ideas have changed, what was reached and where invisible progress is. It is based on an analysis of supporting and coordination actions and key declarations with focus on future strategies in the area of ICT for agriculture, food, rural development and environment. This analysis includes a short overview of the results or recommendations from the projects and studies and a list of previous declarations:

- Aforo Roadmap
- Rural Wins Recommendation
- Valencia Declaration
- eRural Brussels conference conclusions
- Prague Declaration
- aBard vision
- ami@netfood Strategic Research Agenda
- Study on Availability of Access to Computer Networks in Rural Areas
- Future Farms recommendations
- Cologne Declaration

This chapter is prepared as an overview and a review of existing outputs and publications from the above mentioned projects.

2.1 Aforo

The objective of the AFORO [1] project (running in 2002 and 2003) was to provide a vision and work plan to implement future RTD trends for the transformation of agrifood industries into digital enterprises. The AFORO consortium split the agri-food domain into several more "manageable" sectors. Each of them had its own roadmap. The selected sectors were:

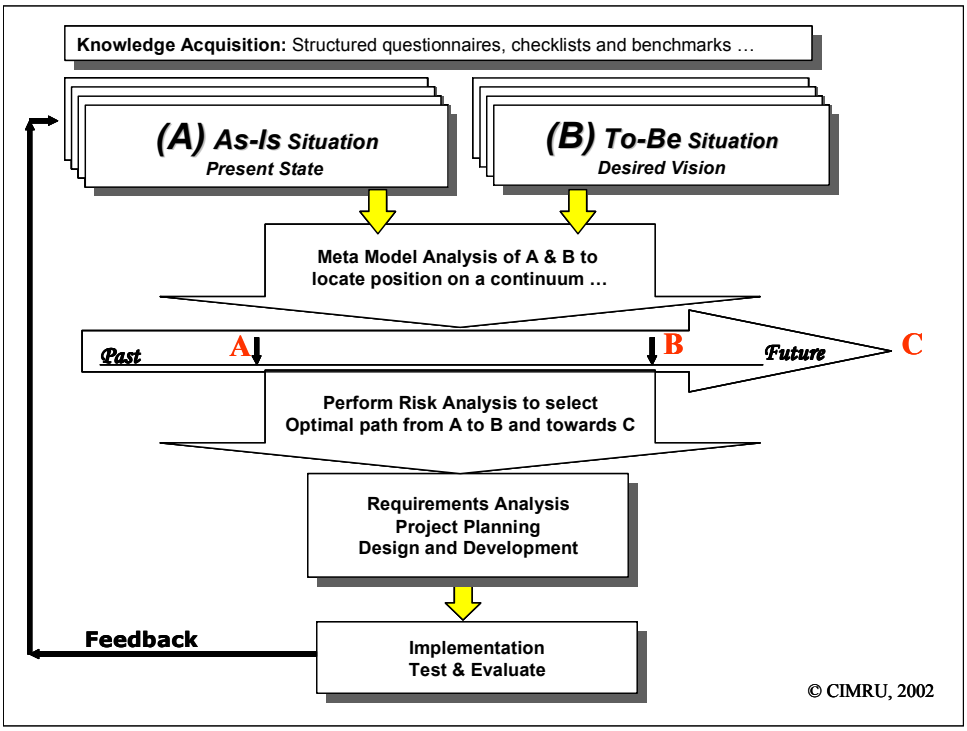
(a) primary sources,
(b) processed food products,
(c) beverages, and
(d) additives, conservatives & flavours.

For every sector the main objectives were:

- to define business needs,
- to identify the main constraints to be taken into account,
- to define technology independent roadmap based on business demands.

The AFORO methodology defined an approach on how the business needs of the agrifood domain can be established in an ordered way. The process was divided in the following steps:

- data gathering,
- ascertaining of current and future objectives,
- analysis of these objectives,
- listing of key drivers [1].



The AFORO project defined roadmapping methodology based on description of situation As is and defining strategic vision To be (see previous image [2]). The important output from AFORO roadmap is consensus of business needs. The following business needs were recognized by AFORO [2].

- To support food traceability and safety over the whole European market chain.
- To implement interoperability technologies enabling networked organizations and forming a Single Food European Market.
- To develop market knowledge supporting innovative value added products, processes and business strategies.
- To design and develop interoperability tools for European logistic and services.
- To design European Agrifood Information System including materials, technologies, and results of RTD activities.
- To support transformation of agrifood business into an effective collaborative organization.

For every issue was analysed situation As is and defined roadmap To be. For detail recommendation see [2].

2.2 Rural Wins

The objective of Rural Wins [3] (2002 – 2003) was to build a strategic RTD roadmap developing an information and communications technologies' vision to ensure the economically and technically feasible deployment of information and communication solutions for rural areas including also maritime regions and islands.

The project provided analysis of:

- the trends in technology development,
- the needed equipment,
- the deployment of services.

Different scenarios of joint public and private initiatives and business models were analysed in order to reduce the discriminatory gap that nowadays exists between rural and urban areas with regard to broadband accessibility and applications' deployment.
RURAL WINS used the European qualitative system of DG REGIO to define and structure its analyses three types of rural areas:

1. Integrated rural areas - territories with growing population, employment basis in the secondary and tertiary sectors, but with farming being still important land use. The environmental, social and cultural heritage of some of these areas, relatively close to big cities, may be under pressure of "urbanisation". The rural character of some of these areas is at risk of becoming predominantly dwelling suburban areas.

2. Intermediate rural areas - relatively distant from urban centres, with a mixture of primary and secondary sectors; in many countries larger scale farming operations can be found.

3. Remote rural areas - areas with the lowest population densities, the lowest incomes and older population. These areas depend heavily on agricultural or fishing employment and generally provide the least adequate basic services. Isolated features are often of topographic character, e.g. mountains, or remote places from transport and communication networks.

For all three types of rural areas, the barriers that need to be addressed by Broadband ICTs are identified as:

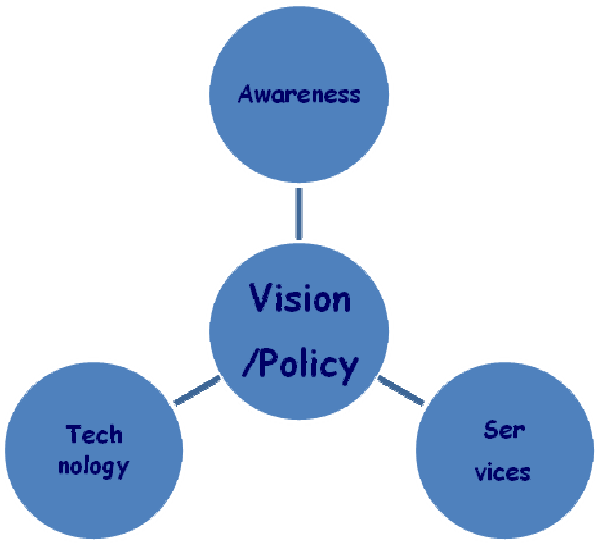
- Distance barriers - access to administrative and governmental services and structures (taxes, subsidies etc.).
- Economic barriers - access to wider business and labour markets (suppliers, customers, opportunities).
- Social barriers of rural inhabitants to information, education & training facilities, health, social services etc.
- Information barriers – currently the amenities of many rural areas are "invisible" to the "outside world" (inhabitants of other areas, urban centres or citizens of other states - rural tourism, local products etc.).

Based on the analysis of socio-economic and technology trends, the project has concluded that for Rural Broadband access is needed:

- Public/Private Partnerships;
- New access technologies.

The project developed a strategic roadmap template that provides a simple, coherent and complete framework to describe the ICT requirements and issues for rural and maritime areas. The framework consists of 4 dimensions:

1. Vision/Policy,
2. Awareness,
3. Technology/Infrastructure
4. Services/Applications



These were identified for each of the RURAL WINS' (a) Integrated, (b) Intermediate & (c) Remote types of rural and maritime areas.

Using this framework, the following concrete scenarios are identified for each type of rural area:

- Integrated areas
  - ICT needs – similar to urban;
  - Recommended – "standard" fibre/wired/mobile/WLAN;
  - Objectives – full parity and use with urban areas;
  - Implementation – commercial;
- Intermediate areas
  - ICT needs – distributed "economies of scope";
  - Recommended – some fibre/wire/mobile/WLAN to towns, satellite/WLAN elsewhere;
  - Objectives – competitive SMEs & access by all to all services;
  - Implementation – public/private partnerships;
- Remote areas
  - ICT needs – part of regional economic, social & cultural development;
  - Recommended – satellite/WLAN - new access approaches are required;
  - Objectives – ubiquitous fixed & mobile services to overcome barriers;
  - Implementation – public funding, public/private & community partnerships.

The use of bi-directional broadband satellite links and local/community owned and operated wireless LANS (particularly Meshs of Wi-Fi (802.11a/b) wireless cells) are identified as being particularly relevant eRural access technologies for remote rural areas.
Rural Wins promotes "eRural" policy. The eRural Integrated project (eRural IP) has to adopt an integrated and multidisciplinary approach across the whole value chain from technology to services and awareness that will cover all RT&D to eliminate the Urban/Rural Digital Divide. [4]

2.3 Valencia Declaration

The Valencia Declaration was the output of the European Conference "Information Society as Key Enabler for Rural Development" organised in Valencia, on 3rd and 4th February 2003. The Valencia Declaration addressed the following items [5]:

- INFRASTRUCTURES AND SERVICES - telecommunications infrastructures must provide the same level of information transmission and of technology and knowledge transfer. Due to low population density and weak economic activity in rural areas, it is necessary to design an optimal convergence model in order to deploy broadband telecommunications networks. Public administration has to support the deployment of such an infrastructure, offering a strategic framework of cooperation and reinforcing the process of telecommunications liberalisation. Member States should address communications infrastructures and their contents in rural areas as a strategic priority. This will require implementation of European Authorities' suggestions regarding the development of information society national and regional plans, through the development of infrastructures (broadband) as well as services. With regards to services to citizens, it must be taken into account that one of the reasons for the depopulation of rural areas is that urban areas provide services to which rural population has no access. The use of ICT could be the key to overcome this situation. Already available but needing to be enhanced, is direct access to administrations (e-Government), particularly the remote delivery of traditional public services, such as health (e-health), social assistance, education and lifelong learning (e-learning).

- TRADITIONAL SECTORS AND NEW BUSINESS OPPORTUNITIES – it is necessary to use ICT in order to gain major benefits through becoming a part of the information society. With regards to the traditional sectors in rural areas (agriculture, livestock, fishing, forestry and food industries) it is worth mentioning the following benefits:

  - Concerning food safety and quality: the use of more efficient quality management and assurance tools as well as training, communication and information applications and government follow-up models.
  - The increase in clearness, transparency and efficiency in agricultural markets as well as in inside sector relationships and in relations among different sectors.
  - The increase in competitiveness by means of a faster adaptation to new market trends.
  - The increase in consumer confidence through the use of tools which enable food traceability, in a way that they will be able to check food safety and quality and that throughout the production process, environmental and animal welfare rules have been respected.
  - The use of e-business tools to concentrate offer and to allow producers to increase their share in the end value of the product.
- KNOWLEDGE SOCIETY FOR ALL - To get rural citizens and companies into the information society they must participate in the general cultural change process, required by this new society model. To this end, the first step to be taken is the development of "digital literacy" initiatives, which will promote the day-to-day use of computers and the Internet. ICT usage levels in companies and homes vary between countries, regions and even counties, but are always significantly lower in rural compared to urban areas. However, it is worth bearing in mind that rural areas are very diverse one from another and show varying levels of socio-economic development. Another factor which must not be disregarded is language. The respect for European multilingual diversity demands actions which contemplate this reality. Overcoming the psychological resistance to technological change must not be underestimated, and will require awareness, training and capacity-building initiatives, while, at the same time, the communication interfaces improve their user-centred and user-friendly character. Moreover, ICT can provide rural inhabitants with cultural and leisure services, that could help to overcome the "feeling of isolation" that is often considered a major cause of young people leaving rural areas. The creation of virtual communities and the recreational uses of the Internet can open a window to the world for rural citizens, while increasing the feeling of belonging to their rural community and identity.

The conclusion of the Valencia Declaration stressed as important to invite all public and private agents to create a new strategic framework of cooperation from which to promote:

- the development of telecommunications infrastructures on an equal basis in all European territories, within the confines of current regulatory legislation;
- the location of new activities in rural areas, as well as the development of value-creation actions for all businesses and services;
- the formation of active policies by those responsible for public administration at European, national, regional and local level in order to ensure appropriate action for the achievement of these objectives;
- multidisciplinary research (technical and socio-economic) to enable a better understanding of the fundamental new drivers of the information society and their impact on rural areas;
- the continuity of discussions, to share expertise and best practices, and to facilitate the progression from a model based on pilot projects to a model that allows successful initiatives to be widely adopted.

2.4 eRural Brussels conference conclusions

As a follow-up of the Valencia conference, the European associations EFITA together with the Czech Centre of Strategic Study (CCSS) and with support of DG INFSO of the European Commission organised one day @rural conference in Brussels. The mission of the @rural conference was to

- facilitate the support for establishing of new European @rural policy,
- exchange information and experience,

- support the development of knowledge in the area of ICT in rural development in order to enhance the competitiveness of Europe,
- promote the awareness of ICT in rural areas of Europe.

The Brussels @rural conference joined representatives of national, regional and local governments, ICT researchers and developers, ICT industry, consultants, specialists for rural development with representatives of the European Commission.
The @rural conference conclusions stressed that ICT technologies offer the possibility to bring new activities, services and applications to rural areas, or to enhance those already existing, providing thus a chance to overcome the barriers and to bridge the widening rural-urban divide. [6].

The development of the information society in rural areas fosters European development and integration, and increases competitiveness of European companies. A region needs a solid foundation for innovation, particularly through an innovation infrastructure with telecommunications and effective use of knowledge. Communications technology enables increased interconnectivity between knowledge workers and companies through virtual networking. Shortages of skills and qualified staff emerge as a major obstacle to innovation. Regions should therefore pay more attention to lifelong learning to facilitate the adoption of new technologies.

The discussed @rural vision supported the stimulation of services, applications and content including modern online public services, e-government, e-learning, e-health services and dynamic business environment. It is important to fund more services, applications and content. Broadband infrastructure provision depends on the availability of new services to use it. This problem is particularly acute in rural areas, where competitive infrastructure provision is not emerging as rapidly as in more central or urban areas. There is thus need for a more pro-active and holistic approach that harnesses latent demand in rural areas for service provision. Getting affordable broadband to areas currently regarded as commercially unviable was mentioned as a "challenge". Such an approach would go a long way to ensure “wider adoption, broader availability and an extension of ICT applications and services in all economic and public services and in the society as a whole”

Conclusions mentioned the importance of tacit and specialised knowledge calls for greater mobility of knowledge workers in rural regions and investment in training and education. Traditional approaches to the production and use of knowledge have to be adapted to this system view of the innovation process in a knowledge society for rural regions. To this end, new relationships must be established between public support organisations, universities and enterprises. In addition to their traditional roles in education and research, universities should promote the transfer and diffusion of knowledge and technologies using ICTs, especially towards their local regional business environment.

As priority was discussed the concept of ambient intelligence that provides a vision of the information society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions.

To assert implementation of European Research Area principles into rural regions, it is important to support research focusing on ICT implementation in rural areas with a critical mass of rural actors, effort and public-private-partnerships across Europe. The eRural research needs to adopt an integrated and multidisciplinary approach across the whole value chain from technology to services and awareness that will cover all RTD&D to eliminate the Urban/Rural Digital Divide.

Among the application topics, the main future challenges were mentioned: eGovernment, environment monitoring and emergency services, food safety, precision farming, controlling of subsidies, application for food industry, ICT solution for forestry and wood industry, eBusiness, teleworking, added value chain, eRural tourism, eHealth, eLearning with special needs for remote areas, the eContent solutions, entertainment, eCulture.

In the communication area, the following important research topics were recognised: mobile systems and mainly WLAN, satellite communication, hyperlan, terminals able to work in different networks.

WEB technologies became an important topic – knowledge management, semantic WEB, personalised WEB, multilingual WEB, distributed system and interoperability including grid technologies (mainly semantic and knowledge grid), data and network security, location based services, GIS and earth observation, visualisation, image processing simulation, embedded systems.

It was recognised, that the current level of development of technologies enables their direct implementation. It was mentioned that support has to be focused not only on research itself but also on the implementation of the research results. The relation between RTD support and implementation support (structural funds) is necessary. It was recognised as important to coordinate activities of DG INFSO, DG Research, DG Agri and DG Regio on European level.

2.5 Prague Declaration

The Prague Declaration was discussed and published at the European Conference Information System in Agriculture and Forestry organised in Prague between 15th and 17th May 2006. The document in the context of a proposed eRural Policy for Europe notes that the current EU Rural Development Strategy for 2007-2013 represents a welcome opportunity for the creation of a Rural Knowledge Society.
The participants declared that the overall eRural Policy Strategy should be based on the combination of a bottom-up and top-down Information and Communications Technology (ICT) development - always rooted in the cultural heritage, needs and desires of the rural communities. This will involve ICT decision makers, developers, providers, end users and other stakeholders.

The imperative aspects are the following:

- Policy and Leadership;
- Research and Innovation Related to the Development of a Rural Knowledge Society;
- Technology Access, Applications and Content;
- New Working Environment Business Models;
- Social and Human Aspects;
- Environmental Aspects.

The Prague Declaration devotes the following objectives:

- Sustainable eRural policies by those responsible for public administration at European, national, regional and local level.
- The support and take up of affordable telecommunications infrastructures and services on a unified basis in all European and other relevant territories.
- The development of value-creating activities supporting sustainable development of new growth areas in rural communities.
- Technology platforms supporting multidisciplinary and collaborative research and development on social, economic and environmental aspects to enable fundamental new drivers of the Rural Knowledge Society. These include assessment and monitoring of their impact on rural areas.
- Further discussions to share expertise and implementation of best practices. [7], [8]

2.6 aBard vision

A-BARD (2005 – 2006) was a Coordination Action that was researching rural broadband provision and use. It was targeted to the needs of rural communities. A-BARD addressed questions close to eRural actors including [9]:

- Rural broadband deployment in rural Europe: issues, models, best practices, affordability and accessibility?

- Broadband applications and services: what is emerging and can some of those applications and services directly address the digital divide?
- A-BARD is documenting emerging results and experience in order to focus and leverage emerging results from on-going RTD, mobile applications and services deployment and ICT take-up.

The aBard recommendations [8] were based primarily on the assessment of work that was undertaken in the A-BARD project, and a synthesis of technological possibilities, market opportunities and the capacity of actors in the regional authorities (to develop and expand ICT based services and applications). This synthesis takes into account the experience of rural areas as a whole and of possible development scenarios in the context of wider EU developments. It provided a perspective on market segmentation in terms of both existing and foreseeable telecommunications products / services. The A-BARD recommendations were structured into four categories:

- Policy aspects;
- Strategic actions;
- Standalone initiatives;
- Further research & innovation.

These needed to balance top-down and bottom-up approaches. They are summarised as follows:

1. Define an ambitious European Rural Broadband Strategy as an integral part of Sustainable Rural Development Policy
    - Allocate public funding where there is “market failure”;
    - In i2010 A European Information Society for growth and employment and FP7, include specific infrastructure, ICT use and RTD initiatives for rural areas;
2. Stimulate business and technical competition in the Rural Broadband Market
    - Every user should have a choice of 2 or more broadband access options;
    - Stimulate Public Sector Demand aggregation in rural and remote areas;
3. Develop sustainable Connected Rural eCommunities to stimulate demand and broadband take up
    - Enhance Regional Leadership and Local Champions;
    - Promote and support awareness (“know what”) and training (“know how”);
4. Provide services and content that rural users want (“killer applications”).
    - Local content;
    - Entertainment;
    - As well as eBusiness, eLearning, eHealth, eGovernment.

2.7 ami@netfood Strategic Research Agenda

The objective of the AMI@Netfood project (2005 -2006) was to support the implementation of the IST Research Priority and Framework Programme, providing a long-term vision on future trends on scientific and technology research oriented to the development and application of ambient intelligence technologies for the agri-food domain. [10]

The Strategic Research Agenda (SRA) outlined activities necessary to support both rural development and in particular agri-food industries. Concerning agri-food businesses, SRA intended to provide a path to facilitate the sector to retain their position as world leaders in providing safe and healthy food products at reasonable cost. The approach taken was to draw upon ICT to support businesses and industry in the agri-food sector and transform it into a Collaborative Working Environment (CWE). In relation with rural development domain, SRA described the needs of the sector and proposes measures in order to implement ICT solutions in rural areas to support their development. The approach selected is not only focused on the development of applications and infrastructures, but also as a means to promote the diversification of rural activities and the promotion of new services through the wide adoption of information and communications technologies [11].

The ami@netfood SRA defined the following challenges:

- Support the European agri-food industry, especially SMEs, to be a worldwide leader in the supply of high quality and safe food products.
- Increase the level of involvement of consumers in the agri-food value chain by means of the wide adoption of relevant IC technologies and applications.
- Increase the areas in which European citizens find collaborative working environments assisted by ICTs by extending them to agri-food industry and rural domain.
- Open new business opportunities for the European ICT industry through development of new applications and tools to support the European agri-food and rural sector.
- Contribute to trigger the investment in ICT and telecommunications infrastructure by means of creating new business models in rural areas.
- Making rural Europe a more attractive place to live, invest and work, promoting knowledge and innovation for growth and creating more and better jobs.

The research and technology development (RTD) domains selected were: [12]

- ICT applications for the complete traceability of products and services throughout a networked value chain.
- Collaborative environments in agri-food and rural areas.
- ICT applications supporting the management of natural resources and rural development creating value for citizens and businesses.
- Innovative ICT applications in rural areas using broadband infrastructure.

The defined RTD objectives were:

- Developing of interoperable integrated intra- and inter-enterprise applications.
- Improving network collaboration.
- Increase the effectiveness and efficiency of knowledge sharing.
- Improve the customer orientated business model.
- Supporting the dynamic network management.

2.8 Study on Availability of Access to Computer Networks in Rural Areas

The DG AGRI “Study on Availability of Access to Computer Networks in Rural Areas” provided policy makers, stakeholders and others with guidance how to maximise the benefits of Information & Communications Technology (ICT) for growth and jobs in all rural areas of Europe, using the support of rural development programmes. The study prepared:

- a database of best practices,
- a review of existing policies and literature Future Farms recommendation [13].

On the basis of the analysis a set of recommendations with focus on maximisation of the benefits of ICT for rural development was prepared:

- A coherent eRural strategy as an integral part of sustainable rural development policy, focusing on building capacity, even though this often produces “softer” outputs;
- Improvement within the eRural strategy of control and monitoring of ICT indicators, policies and initiatives including the collection of coherent statistical data;
- Measures which stimulate business and technical competition at different levels of scope and sophistication within the rural broadband market;
- Developing sustainable connected rural eCommunities to stimulate demand and ICT take-up – particularly by enhancing regional leadership and local champions to ensure that ‘bottom up’ projects flourish, and by supporting awareness (“know what”) and training (“know how”);
- Providing services and content that rural users feel are pertinent to them, especially entertainment and local content, as well as policy priorities such as eBusiness, eLearning, eHealth and eGovernment services;
- Encouraging initiatives which promote the theme of eCommunity, particularly by way of a common eRural agenda;

- Adopting a rubric of best practice at the interface between LEADER and those seeking access to funding;
- Extending investment in broadband infrastructure to all local public sector agencies and schools;
- Investing and developing the content of local networks;
- Raising the digital e-skills of local businesses and citizens;
- Introduction of an eProcurement process with appropriate safeguards and innovative proactive online support to fast-track ICT projects in rural areas;
- Explicitly encourage the role of local authorities in laying ducts and then renting them to operators on an open and non-discriminatory basis, and promoting indoor pre-cabling for all new buildings in their regions.

Review adds new factors to those identified in previous research:

- A shared sense of lagging behind, which can be stimulated constructively by a local 'champion';
- Being spurred on as a consequence of a successful local enterprise;
- Being encouraged by the experience or ICT familiarity of others;
- Following a targeted intervention which demonstrably has improved the local quality of life;
- Emotional responses for local, personal reasons;
- Local resistance to an imposed agenda; [13]

2.9 Future Farm vision

Future Farm was a European project funded by the EU as part of the Seventh Research Framework Programme. It ran between 2008 and 2010. The main aim of the project was to make a vision of future arable farming. [14]

The project recognised that the future farming and also future farming knowledge management system will have to solve many problems, where there will be very different requirements on production, but also on strategic decisions. There exists a list of influences and drivers that will also influence farming. For example, requirements on food quality and safety in opposition with requirements coming from growing population and on renewable energy production technologies. The project also highlights that in some cases production on renewable production energy can have negative influence on the environment. It is important to introduce a new knowledge system that will help to solve such problems.

By 2030 the importance of biotechnology will grow and research results could be transferred on farm level. There will be two important trends: requirements on quality of production (high quality food, vegetables and fruits and also growing demand on special food) and on environmental friendly production on one side and increasing demand on amount of production on the other side.

The project expects that two main groups of farm will exist in 2030:

- Multifunctional farms.
- Industrial farms with focus on high efficiency and high quality of production.

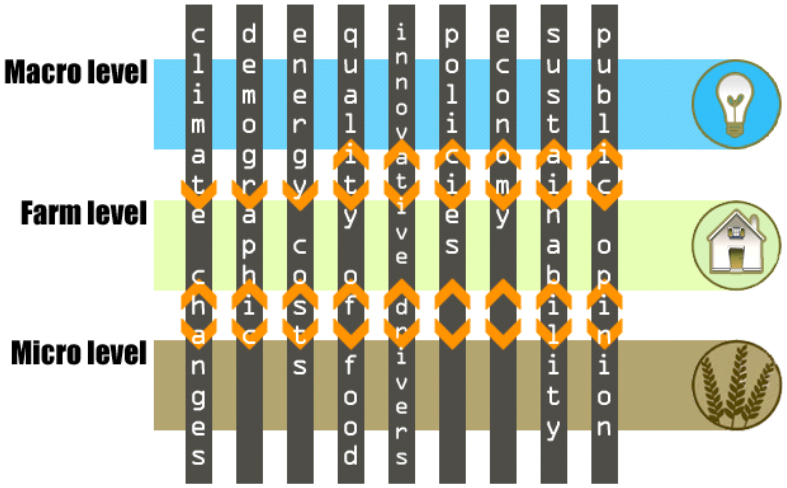
The focus of the multifunctional farm will be on efficient agriculture from an environmental and socio-economic point of view. But the future of the multifunctional farms will depend on public dialog and valuation of non-production goods.

The focus of the industrial farm will be to produce enough food and energy in a sustainable way which meets the consumer's demands. The quality of food will be important in Europe and it is expected, that also bio production will be industrialised or will become knowledge intensive. The expectation is that the industrial farm will be able to exist without subsidies, but it will dependent on the level of restriction. Science will be the key driver.

In 2030 agriculture will become fully knowledge driven. This will require full adoption of ICT. New sensors and nanotechnologies will become part of management. ICT facilitated the development of robotics and automation now used in many industries including the agri-food sector.

On architecture level of information systems, we recommend to be focused on service oriented architecture, which could guarantee better connection and interoperability of future systems. It will influence used GIS systems, better acceptation of XML standards, but also importance of robotics will grow.
For adoption of new technologies, it will be important to focus on two horizontal issues: education and standardisation. Without educated staff it will not be possible to introduce new knowledge intensive methods. Standardisation importance will grow for interconnectivity of different levels of farming knowledge systems. [15], [16].

From the point of view of Future Farming, it is necessary to take into account previous analysis for suggestion of future knowledge management system functionalities and interrelation. The basic principles of interrelation could be expressed by the following image (coming from [16]).



The image expresses the task for knowledge exchange on different levels. By studying of this schema we can expect the following transfer of knowledge.

Climate changes
Macro level
There will be a need for a long time modelling of influences of global climatic changes on production in single regions. It is not only a focus on a selection of best crops and their varieties, but also analysis of new pests or insects. It will be important to analyse and predict the needs for irrigation. In short term, it will be necessary to predict extreme weather events.

Farm level
Prediction model for climatic changes in middle term period (minimally for one season, but better for three or five seasons) will be important aspect for changing of strategy on the farm level. There is no possibility to change arable production during the season. It is better to continuously move to a new production.

Micro level
With changing climatic conditions and with higher probability of extreme local events the importance of local monitoring and local weather forecast for short (weeks, month) time period will grow. Use of new sensor technologies and local forecasts systems will play an important role.

Demographic

Macro level

On macro level it is necessary to forecast the amount of food that will be necessary worldwide and regionally only. This forecast should enable in middle term perspective from one till five years for farmers adapt their production for next season, but also to provide some changes for next years. It is also necessary to provide short time forecast of yield during season to be possible for farmers to optimize their marketing strategy in common season.

Farm level

The seasonal forecast of yield has to be used on farm level for optimizing other costs of production during the season. Middle term forecast has to be used for optimization of farm production (selection of crops, varieties, crop production focus). Other important aspect could be to decrease the demand on labour resource by better farm management and logistic with robotic introduction and size of robots implementation.

Micro level

The short and middle term information about yield demand will require adding used model of precision farming. It is not possible to implement one model. This will be necessary to offer different possibilities, like maximize yield, to keep good yield quality, to minimise costs (to keep soil sustainable development), to optimise farm profit for future farm development, etc. Robots' implementation helps to solve problems with time needed for data collection, accuracy, objectivity of data collection and labour resources.

Energy cost

Macro level

From the development of costs of energy in the last year, it seems that costs of energy are not predictable. But in long term we can expect that the cost of energy will grow. There will be a need for prediction of the development of energy costs. The cost of energy will be important from two different reasons:

- Energy costs will influence costs of production.
- Energy costs will be important for decision.

Farm level

- The new knowledge management system on farm level has to be focus on three aspects:
- How to decrease cost consumption, which will be focused on farm management strategy and improving of logistic.
- To use such machinery that will guarantee lower energy consumption for the same amount of work.
- Decision about optimal crop composition.

Micro level

- Development of energy cost will influence farm management on field level in next aspects:
- Optimisation of energy consumption using robotic technology.
- Use PF technologies in new direction to decrease energy costs as for example precision seeding or precision crop protection.
- With potential energy production will be necessary to change the PF models like in previous case.

New demands on food quality

Macro level

There will be necessary to collect and analyse information of consumer behaviour and consumer requirements in the direction of food quality or specific diet requirements. It will be necessary to qualify and also quantify the willingness of population to pay for certain quality of production or for

certain products. Currently, for major population costs of production are the main criterion. This criterion is in relation with economic situation of single citizens and globally with economic situation in countries.

Farm level
The main decision on farm level will be whether it will be better to orient farm production of lower amount of high quality of yield with higher prizes or higher amount of lower quality of yield with lower prizes.

Micro level
The new food quality demands will have on field level next influences on knowledge management systems:

- Using new tools of traceability to give evidence about quality of production.
- To use new PF algorithms to guarantee higher quality of production.
- To use new technologies like robotics to guarantee more precise fertilisation and crop protection.

Innovative drivers
Macro level
From innovation point of view, it will be necessary to offer information to farmers about new crops that could be used for concrete climatic or geographic conditions, about hey resistance productivity etc. It will be important to give farmers an access to new possibilities of using different crops for energy production, different bio products and use of different crops for example in pharmacy.

Farm level
The information about new products has to be used for optimal selection of sorts in relation with geographical and climatic production. The information about needs for different crops for non food production and also their prizes has to be used for decision, which will be orientated of farm production.

Micro level
On micro level, PF methods should be able to adapt for specific requirements of new sorts.
It is important to introduce new methods of traceability, which will guarantee usability of crops for specific bio production and in pharmacy. In order to develop new technologies like robotics, which will guarantee better fertilisation and protection, which will be required by new crops or for new kind of production.

Development of sustainable agriculture
Macro level
On macro level, there is a need to guarantee access of farmers to information about possible payment and the possibility of environmental valuation. It is important to take into account that if farmers will play role in environment protection, they will need to have a profit from it. It is necessary to offer them concrete values, which they will obtain using certain methods of production.

Farm level
The knowledge management system has to support the following tasks:

- To define optimal methods of production (selection of crops, crop rotation, etc.) to guarantee long term sustainability of the production and protection of quality of soil as the mean of production.
- To support decision. If the farmer will be more oriented on classical intensive production or on the methods of environment protection of production. It has to be done on the concrete level of environmental valuation.

Micro level

The knowledge management on micro level has to cover the following tasks:

- Monitoring of soil quality.
- Precision farming methods, which will guarantee protection of environment.
- Traceability tools giving evidence of used methods.

Policies

Macro level

The knowledge about changes in policies, standards, changes in subsidies has to be transferred into such forms that could be easily acceptable by farm management systems. Policies, subsidies, standards are usually not possible to change on lower level, but they represent some level of limitation. It is necessary to transfer this knowledge into decision supporting systems on farm level as a limitation. There is necessary to support subsidies management and controlling system.

Farm level

It is necessary to include limitation given by policies as components or limitations for decision support system on farm level. It is necessary to analyse and collect information that is required as evidence from governmental bodies.

Micro level

The knowledge management on field level has to guarantee traceability and all monitoring of all parameters that will be required by legislation.

Economy

Macro level

It is necessary to collect knowledge about costs of inputs on market and also about prizes of products on the market to give chance to farmers to adapt their behaviour. It is necessary to provide integration of information in vertical and horizontal agri-food chains and also integration of knowledge among farmers, advisory and service organizations using common workspace to guarantee effective cooperation.

Farm level

There is a need for decision support system, which will be able, on the basis of economical information from market, to analyse possible changes in production, selection of suppliers and to select to whom to sell the production. It is necessary to give the possibility to share a part of the information in horizontal and vertical chain.

Micro level

The PF tools have to guarantee effective exchange of information with suppliers.

Public opinion

Macro level

Public opinion could have influence on consumer behaviour, on the costs of products on the market, but also could influence policies (for example global warming problem). It is necessary to analyse different public opinion campaigns and analyse their possible influence on the market.

Farm level

On farm level, it is necessary to include as one from inputs of DDS possible influences of public opinion campaigns on market.

Good traceability on all farm levels has to be supported.

Micro level

Support for full traceability.

Active participation in IT related standardisation activities will also be necessary in terms of facilitating that work related to standards do comply with the users long term requirements. Here, having the input of rural users to future standards and regulations will facilitate a faster take up of ICTs.
The main conclusions of the vision for Future Farm knowledge management system are:

- Both directional knowledge transfer among macro farm and field management level;
- Main decision has to be provide on farm level;
- Use standards for communication among levels;
- Use Open Service Architecture;
- For decision system give possibilities;
- To select suboptimal variants;
- To use non deterministic methods.

In order to provide optimal decision, the system needs to have an access to as much knowledge from global level as possible (the different macro knowledge was mentioned before). Any missing knowledge could have influence on the final decision. There exist many limitations, but also many freedoms for decision. It is necessary to mentioned one risk. If all farmers will use the same input knowledge and the same deterministic algorithm, the usage of such decision could lead to distortion of the market. There exist two possible options, which could guarantee non uniform decision:

- To use suboptimal variants.
- To use non deterministic methods for decision.

2.10 Cologne declaration

The Cologne Declaration was prepared at the European conference GeoFARMatics 2010 in Cologne in Germany, which was organised by the EU-funded projects FutureFarm, agriXchange and the CAPIGI network. The Cologne Declaration recognises that agri-food and rural ICT must be an essential part of the European Digital Agenda for 2020. New changes in the global food supply, growing demands on food quality and quantity, energy demands and environmental aspects introduce new demands on future knowledge management. The objective of future knowledge management has to be focused on the agri-food and rural communities to be able to react adequately to these changes. For this reason, knowledge management has to become part of the agri-food and rural production system. This requires a clear vision, which has to be based on discussions with farmers, experts, politicians and other stakeholders. The single digital market, Future Internet, sharing of knowledge, social networks, protection of data and open access to information will be essential for farming and rural communities.

The imperative aspects are the following:

- Policy and Leadership
    - including representatives of ICT for agriculture and rural development specialists into the legislative processes of the European Communities leading to the definition of priorities of the Digital Agenda;
    - raising awareness and establishing a social platform for exchange of information among key participants, especially rural communities;
    - supporting a platform for standardisation of information inside rural communities and the agri-food sector but also between the agri-food sector and other sectors;
    - including rural knowledge management as an essential part of the future European Strategic Development plan;
    - building a coherent strategy for rural public sector information management.

- Research and Innovation - The development of knowledge-based systems for the farming sector has to be supported by ICT focused on:

- Future Internet and Internet of things including sensor technology and machine to machine communication;
- Service Oriented Architecture as a key element of architectures for future knowledge management systems;
- The power of social networks and social media or so called knowledge internet;
- Management and accessibility of geospatial information as a key information source for any decision;

On the application side the focus has to be on:

- ICT applications for the complete traceability of production, products and services throughout a networked value chain including logistics;
- Collaborative environments and trusted sharing of knowledge and supporting innovations in agri-food and rural areas, especially supporting food quality and security;
- ICT applications supporting the management of natural resources and rural development.

- Future Technological Solutions - Future Internet architectures must reflect the needs and specificity of rural communities. It has to be resilient, trustworthy and energy-efficient and designed to support open access and increasing heterogeneity of end-points. Networks should sustain a large number of devices, many orders of magnitude higher than the current Internet, handle large irregular information flows and be compatible with ultra-high capacity, end-to-end connectivity. Service Oriented Architectures have to provide methods for systems development and integration where systems group functionality around business processes and package these as interoperable services. The future development of technology has to be based on a broader utilisation of social networks. It is important to support the development of machine-readable legislation, guidelines and standards to integrate management information systems with policy tools.

- Standardisation - Integration and orchestration among services based on semantic integration of collaborative activities, including semantic compatibility for information and services, as well as ontologies for collaboration will be a major priority for future solutions.

- Social organisation of knowledge management - The concept of Trust Centres has to represent an integrated approach to guarantee the security aspects for all participants in the future farm. There will be a growing importance of protection of privacy and I Intellectual Property Rights (IPR) because trust of information is one from the priorities for all rural communities. Pan European Social Networks have to support trust centres and enable such technologies as cloud applications and which will have to guarantee knowledge security.

- Social and Human Aspects - Rural businesses are usually small or medium size businesses according to the number of people they employ and so knowledge management and internal processes are different from large companies. Future knowledge systems have to be based on each community's own concepts of value, cultural heritage and a local vision of a preferred future. The objective is to develop human-centred reference models of sustainable rural life-styles that overcome social divisions and exclusion and include unique rural features and create new rural businesses and social infrastructures and attractive computer-based education.
- Environmental Aspects - Societal and political pressures for increased environmental standards are expected. It will be necessary to discuss such aspects as the utilisation of GM production and environmental aspects of bio fuel production. These aspects will, on one side, require exact economical, health and environmental mathematical analysis and, on the other side, public discussion and e participation on such decisions.

The Cologne Declaration entreats all public and private agents to create a new strategic framework of cooperation to promote:

- Defined key objectives for the agri-food and rural Digital Agenda for 2020;
- Support for the development of future internet technologies and the internet of things;
- Support for social networking to reach consensus about future environmental, economic and social priorities of agri-food and rural strategies;
- The initiation of a continuous e-conference of all stakeholders to define a clear future strategy and priorities;
- Support for new ICT and knowledge-based solutions supporting the development of future generations of rural businesses;
- Support the development of knowledge technologies to guarantee, in the future, high quality food production;
- Open public discussion on how to solve future problems and to secure food production versus the production of energy and environmental benefits. [17].

2.11 ICT Agri

ICT-AGRI is the 7th Framework Programme for Research ERA-NET project. ERA-NET has to develop and strengthen the European Research Area in the area of ICT for Agriculture through practical initiatives coordinating regional, national and European research programmes in this field [33]. There are four objectives of ICT-AGRI:

- Mapping and analysis of existing research and future needs;
- Development of instruments and procedures for transnational funding activities;
- Development of strategic transnational research agenda and programmes;
- Establishing and maintaining of international collaborations and networks.

Till now three main results, which are important for AgriXchange, are:

- ICT-AGRI Fact Sheet;
- Analysis of existing research and future needs identified by French actors;
- Reports on the organisation of research programmes and research institutes in 15 European countries.

There are important facts recognised by ICT-AGRI Fact Sheet:

- The agricultural sector is currently facing a conflicting challenge: to produce more food and maintain high food quality and animal welfare standards while reducing agriculture's environmental footprint.
- Information and communication technologies (ICTs) can help farmers address these issues, but European research on the use of ICTs in agriculture is fragmented.
- The ICT-AGRI is trying to coordinate European research in this important area to ensure that the massive potential of ICTs in the farming sector is not wasted [34].

Inside of ICT Agri project the French national network has identified the following challenges:

- Obvious lack of interfacing tools able to manage and use "intelligently" the knowledge bases provided by the many data collection systems.
- Need to develop "global information systems" to monitor and run the farm that include all the levels (e.g. for livestock production: management at animal, herd and farm levels) and beyond the farm (e.g.: "quality" traceability after processing).
- Too specific an offer from software manufacturers and one that is insufficiently interoperable
- Shortage of software designed to manage the fleet of equipment and sites.
- Emphasis to be placed on the exporting/sharing of information among all the actors in the production sector as part of a "paperless" approach.

- Encouraging the development of open source software and related interfaces.
- Necessary development of models and tools allowing for planning, supervision, forecasting and decision support.
- Building of operational decision-making processes.
- Computer models of farms helping to analyse and to devise work organisation methods and, more generally, resource management.
- Necessary development of new sensors.
- Development of research on wireless sensor networks.
- Concern for managing the energy autonomy of sensors.
- Need to move towards a greater integration of automated systems in the farm's global information system.
- Effort required to have systems that are easy to use and within the reach of end-users.
- Inclusion of integrity/security dimensions essential for the dissemination of automated and robotic solutions on the market.
- Special responses to be given to certain specific production sectors at national level like Wine growing/tree cultivation, Forestry sector, Organic matter spreading, Confined animal production systems.
- Need to develop fresh disruptive approaches combining performance and production quality.
- Need to develop model-based anticipatory and predictive control systems.
- New technologies derived from robotics to do away with hard, tedious tasks.
- Special requirements of the agronomic risk management chain.
- Ever obvious shortage of interoperability, both for data collection systems and for system software packages.
- Need for financial support to encourage actors to take part in standardisation groups.
- Need to have methods and results for the performance assessment of systems proposed for Precision Agriculture and Precision Livestock Breeding, with a multicriteria approach.
- Need for collective dynamics between users and suppliers and for collective organisation methods to be developed promoting the dissemination of these technologies.
- Promote a "use-centred" design approach.
- Re-examination of the value chain.
- Seminal effect of the "Energy" dimension.
- Facilitator effect of new environmental requirements.
- Possibility to reduce investment levels by pooling certain technological components.
- Advisable to take into account the uncertainties regarding sensor data and related processing.
- Strongly advisable to set up both initial and continuing training modules [35].

The country report of ICT Agri was focused on next areas:

- ICT applications to be used in primary agricultural or horticultural production, including online resources.
- Automated or semi-automated machinery, equipment for primary agricultural or horticultural production.
- Standardisation of data dictionaries and communication protocols for use in primary agricultural or horticultural production.
- ICT and automation in environmental regulation of primary agricultural or horticultural production.

- Effects of ICT and automation on competitiveness, profitability, and environmental impacts of agricultural or horticultural production.
- Business structures in sale and support of ICT and automated machinery in agricultural or horticultural production.

The country report includes 210 research institutes relevant to the ICT-AGRI research area. The country report also has some important limitations. During the next mapping step, done via the ICT-AGRI Meta Knowledge Base, more specific information about research projects and profiles of researchers and research organisations will be mapped. The result will give a clear overview of the current strengths and gaps in the research area of ICT and robotics in agriculture and agri-environment [36].

2.12 agriXchange analysis of data exchange in agriculture in the EU27 & Switzerland

The report highlights the results of research on the current situation of data exchange in EU member states and Switzerland. The current situation was a compilation of a literature review and investigation of the state of the art in these countries.

In arable farming so called precision agriculture is one of the driving forces for data exchange and issues related to data formats and interface standardization. Currently, new automation, ICT and GIS technologies provide solutions for steering and controlling site-specific production systems to fulfil requirements of safe, efficient, environment friendly and traceable production. To enable compatibility between different system parts that are needed in performing PA, an information management system which utilizes open system interfaces and ICT standards, such as ISOBUS, and efficient data transfer are required.

Much effort has been placed towards spatial data harmonization in the past and positive results are emerging especially in efforts towards standardisation work of the Open Geospatial Consortium, Inc. (OGC) and ISO/TC211 Geographic Information/Geomatics. Another relevant harmonization work is related to the INSPIRE Directive. The scope of standard development of ISO/TC 211 is also relevant and includes information technology, GIS, Remote Sensing (RS), Global Position System (GPS) and other advanced concepts, models, patterns and technical methods. Geography Markup Language (GML) identical to ISO standard 19136:2007 provides a variety of kinds of objects for describing geography including features, coordinate reference systems, geometry, topology, time, units of measure and generalized values.

The implications of ICT and data transfer in livestock production directly affect consumers in terms of awareness and knowledge of consumers, information transfer for food safety, animal health and welfare, efficient plant and animal production and sustainability of production systems. Expected ICT developments in the coming years include developments towards external storage of farmer's data tocater for increasing amount of data produced. Centralized management information's systems, with internet-based cloud support are foreseen.

Geographical Positing Systems (GPS) is seen to become a of future agricultural technology in terms recording field data collection, yield mapping automated Variable Rate Applications (VRA) in seeding and fertilizing amongst others.

According the results of the research, arable farms are largest in the Czech Republic, Denmark, UK and France. The largest dairy farms were in Denmark, Cyprus, Czech Republic and the UK.

Farm automation level: by characterizing precision farming (PF) as a measure of farm automation, in most EU countries, PF is only used to a small extent by farmers. However, there is a significant difference in areas across Europe, in Western and North Europe and for example in Czech Republic

there is more progress in PF development. Manufacturers of agricultural machines are the main booster for adaptation of PF techniques in developed countries such as Germany, the Netherlands, Denmark and Finland.

In general big differences all over Europe can be seen in data integration at process level. The availability and accessibility of (broadband) Internet in rural areas is an issue in most countries. Except from some countries like Germany, France, Denmark, Belgium and the Netherlands, no (private) unions or bodies are reported who take care of the organization of dataflow or standardization.

In many EU countries data definitions (semantics) have only public standards (XML schema's and web services for example) mentioned. Standards definitions such as ISOBUS are available for example machinery (ISObus), milking equipment (ISO 11788 ADED), electronic animal identification (ISO 11784/11785/14223 and 24631) or forestry (ISO 19115). Syntaxes for EDI messaging from agroXML (Germany, some other countries), ISOagrinet (international), Agro EDI Europe and Edaplos (France), AgroConnect (The Netherlands) were reported. However, data integration along the whole food chain from farm to consumer is still lacking.

Analysis of the European area points out that it can be divided into four different levels of maturity on data integration. The levels are; countries with none or hardly any data integration, those with poorly developed data systems, countries with rather well developed systems and countries with quite well developed data integration systems.

Education and demonstration about new technology adaptation, agricultural software, available databases and digital information sources can help farmers to develop usage possibilities. Also implementation of the (most easy) best practices from other EU regions in addition to utilization and connections to existing global standards is needed.

Private businesses need coordinated organization in setting up integrated systems for agriculture.

Countries with rather good data integration (Scandinavian states, CZE, GBR, IRL, BEL, CH) were reported to demonstrate progressive involvement by private organization within the past years.

The final level, level 4, are countries with fairly well developed data integration (FRA, DEU, NLD, DNK). In these countries, system assessment and move towards open/shared communities is already in place. Infrastructure based on hub structures (such as in communicating and transporting systems) are also available.

The high-technology, high agricultural diversity cluster appears countries like Finland, Spain, Germany and Italy. They are characterized by a fairly high degree of organization among stakeholders in agricultural data exchange and good technical infrastructure availability.

Networking challenged cluster includes countries like Belgium, Denmark and the Netherlands. Within these countries, open cooperation, also on the international level is an issue. Overcoming the situation can be achieved by forming open networks and enhancing exchange of knowledge, technologies and information between the public and the private sector.

The infrastructure challenged cluster consists of the countries Bulgaria, Greece, Ireland, Latvia, Lithuania, and Portugal. Within these countries, wireless broadband connectivity or even basic internet connectivity needs to be enhanced in rural areas. Information and education about agricultural software, available databases and digital information sources can help farmers to develop a view on benefits and usage possibilities.

To cater for the disparities technological adaptation in different sections in the EU regions, the following recommendations are given. In regions with most small farms and poor farmers usually no standardization and hardly any ICT is available, it is recommended that data structures should be organized by public services to get developments started. The import of systems and data standards

through private business (through multinational trade) will help as well. Last recommendation for this region is to copy knowledge (learn) from obligatory public services from other countries with structured and standardized ICT systems for agricultural data transfer. For the regions where a focus on ICT is highly related to basic local challenges for example challenges with water management, erosion (in Southern parts) or trade (more in Western- and Northern Europe).

Regarding water management the implementation of best practices from other countries and the implementation of integration GPS and sensor data, smart phone apps for easier data access are mentioned. The regions with problems related to aging of farmers hence low rates of adaption of ICT by farmers, it is recommended in these countries that the effect of adapting new technology should be demonstrated, and reinforced by education, not only for learning purposes but also to create a new and enthusiastic working environment for younger aged workers

Build reliable public (CAP) services and extend them with Web Services to provide private business with development opportunities for standardization and practical implementation CAP in the EU countries. International initiatives are needed to and stronger countries in ICT should take the lead in new international data integration initiatives and use international/global standardization bodies like ISO or UN/CEFACT.

Combine/redesign the best of several standards in different nations, like EDI-teelt – agroXML - EDaplos.

In closing, the following general conclusions are given as big challenges in data exchange currently and in future. For improving business in the agri-food supply chain networks, investment is needed in creating trust and awareness in the chain, adoption of new technology by means of open innovations are needed, new collaborative and service-oriented infrastructure are to be developed, implementing business process standards and service-oriented approaches should be practiced, and standards set against the backdrop of current EU policy should set, chosen and adopted. As policy implications controlling efficient data inquiry for boosting CAP in the EU is crucial. EU or national governments should play active roles directing the development of data standards. Private-public partnership is needed to address issues with limited investment possibilities, especially in small domains and countries. Involvement of public organisations in the setup of (private-public) collaborative data infrastructure can be achieved through the initiation of common data structures in the EU, through the initiation of (further) research on the implementations of common data structures and through stimulating availability of (broadband) internet infrastructure and capacity in rural areas. It is discussed that the investigation was meant to provide an overview of the state of the art in data exchange as bias for further project work.

The identification of key factors for the added value generated by a common data exchange system was not precisely elaborated. The quantification of the benefits arising from overcoming these barriers is beyond the scope of this analysis. Discussion of the meaning and value of data exchange will continue in the course of the project.

Finally, as a recommendation, benefits arising from overcoming the barriers discussed in this report should be quantified through future research. The effect of adopting new technologies needs to be clearly demonstrated in EU countries and societies. Data integration through open networks should be actively organized in these near years [37].

2.13 Conclusions from the overview of past activities

In our analysis we looked only on several projects and documents focused on a vision of future ICT for agri-food or eventually ICT for rural development. There were a number of really technological projects, which are not mentioned (WirelessInfo, PreMathMod, c@r, COIN IP, Smart AgriFood). The

results of these projects are already partly overcome, and results or technological visions of some of them will be used in next chapters.

If we compare the changes in recommendations during the last ten years, we can see the biggest progress in deployment of communication infrastructure. The progress in deployment of infrastructure in Europe was very fast and changes from one year to the other were visible. About big part of Europe we can say that anybody has potential access to broadband, that there is a complete coverage of Europe by GSM and large parts of Europe are covered by 3G technologies. Important phenomena become WIFI technologies. Through WIFI hotspots you have the chance to connect to the Internet in many places in Europe. From technologies the potential of WIMAX (Worldwide Interoperability for Microwave Access) is not used in full scale yet. There is approximately 10 years of delay in developing countries in the implementation of the infrastructure. But current status shows fast development of mobile networks.

Already "Study on Availability of Access to Computer Networks in Rural Areas" recognised that the take up of new solutions into practice and also research in agri-food and rural applications is slower than deployment of the infrastructure. We can see that application priorities are not changing so fast. For example some priorities including support for networking of organisations and support for traceability can be seen as a major priority for the whole period. The big problem is information exchange and interoperability. The reasons of these problems are:

- In many analysed studies social aspects were mentioned, in many countries the rural population is older with lower education than urban communities. This is one from reasons of low take up in rural regions.
- Till now the connectivity in rural regions is lower.
- If we are looking on agri-food sector, we can recognise one important difference. Food market is globalised and food market requires global information. Till now agro production is mainly locally oriented and is working mainly with local information. The use of global information in farms is limited. There is also a problem, that farming software is fragmented and usually is developed by local developers. There is exception like precision farming system developed by big machinery producers, but usually this software covers only small segment of farming production. It was already recognise by Future Farm and ICT Agri, that future Farming decision making has to be built on global information and that in future this global information will be necessary for farm competitiveness. This will also help to farming sector to compete with food sector, which is acting locally.

If we are analysing all the previous results, we can recognise one other important fact. The research in ICT for Agri-food sector is diversified and different research group are not acting together. We can see that in many projects the same exercise with similar results are repeated and usually there is not long term sustainability for the ICT Agri-food research.

The allocation of resources for the ICT for Agriculture research is another issue to be solved. The financing is partly coming through the ICT programme, partly through the KBBE programme. The current programmes are particularly focused on ICT in agriculture and it would be useful to to organise a cross-programme joint calls focus on research in this area.

As a conclusion from the overview of past activities, the following areas are necessary to support:

- The take up of new technologies in primary production.
- Long term suitability of research and support for long term vision for RTD development in the agri-food sector.
- Better implemention of RTD results into practice
- Strong professional organisation which will unify different efforts of different research and development groups, but which will be also able to protect interests of communities. The candidate for such organisation could be EFITA, but there will be necessary to change its organisation structure.

3 Future Internet, standardisation and future challenges for ICT for Agri-food

What are the future challenges? What will influence the future rural development and farming sector? What could be the future trends? What will be the future of rural ICT in the period until 2020? What are the expected changes in ICT infrastructure? How they will be innovation driven? What are the ideas about the future ICT technologies? We will try to find some ideas on the basis of the work of the c@r, COIN IP, FI-WARE, Smart Agrifood and agriXchange projects.

3.1 Agri/food and e rural Challenges for future

In next period, rural Europe will be radically transformed in terms of the distribution of people and of economic activity and Gross its regions. These changes are inevitable. A common and future position of each important driver in reality can be different. In many cases two drivers can act against each other and their future influence on agri-production and food market depends on regulations and common policy. For example:

- Food quality and safety ⟺ Food requirements for growing population.
- Growing requirements for food ⟺ Renewable energy production technologies.
- Renewable production energy demand ⟺ Demand on more environmental-friendly production.

The combination of externals drivers will introduce new challenges for future agri production and also for all rural communities. We can recognize a list of challenges, which has to be reflected by future farming knowledge management systems. We can name the following challenges for future:

1. **To include ICT and knowledge management for agri-food and rural communities generally as a vital part of the ICT policies and initiatives** (for example Digital Agenda for Europe 2020). Previous analysis in this report demonstrated that there exists an ICT gap between urban and rural. This gap is more visible in developing countries, but also in Europe, North America, East Asia and other countries. Newly coming solutions such as the single digital market, future internet, globalization of knowledge, social media and networks, protection of data and open access to information will be essential for farming and rural communities. Knowledge becomes one of the most important products and also material. If there is no equal access to knowledge by rural communities, the urban rural gap will grow and negative trends will continue e.g. abandonment of rural areas.
2. **To find a balance between food safety and security, energy production and environment production** – As it was mentioned in previous chapter, current agriculture and food production is subject to many different requirements. On one side, worldwide growing population brings new demands on food, but also on arable land, water, energy and other biological resources. There is a growing demand for energy and production costs of energy.

On the other side, there exist requirements of citizens and markets on higher quality of food production, but also on new products. It is related with aging population in some part of the world, but also with ethnical and cultural changes (migration of population). All of them have a strong influence on global ecosystem and environment generally. The influence is bi-directional and some issues like climatic changes, draughts, floods etc. have also large influence on production. We need to find a model of sustainable agriculture production based on synergies and trade-offs across the economic, environmental and social impacts. This will require tofind new methods of production, but also increasing the level of involvement of citizens in the agri-food value chain.

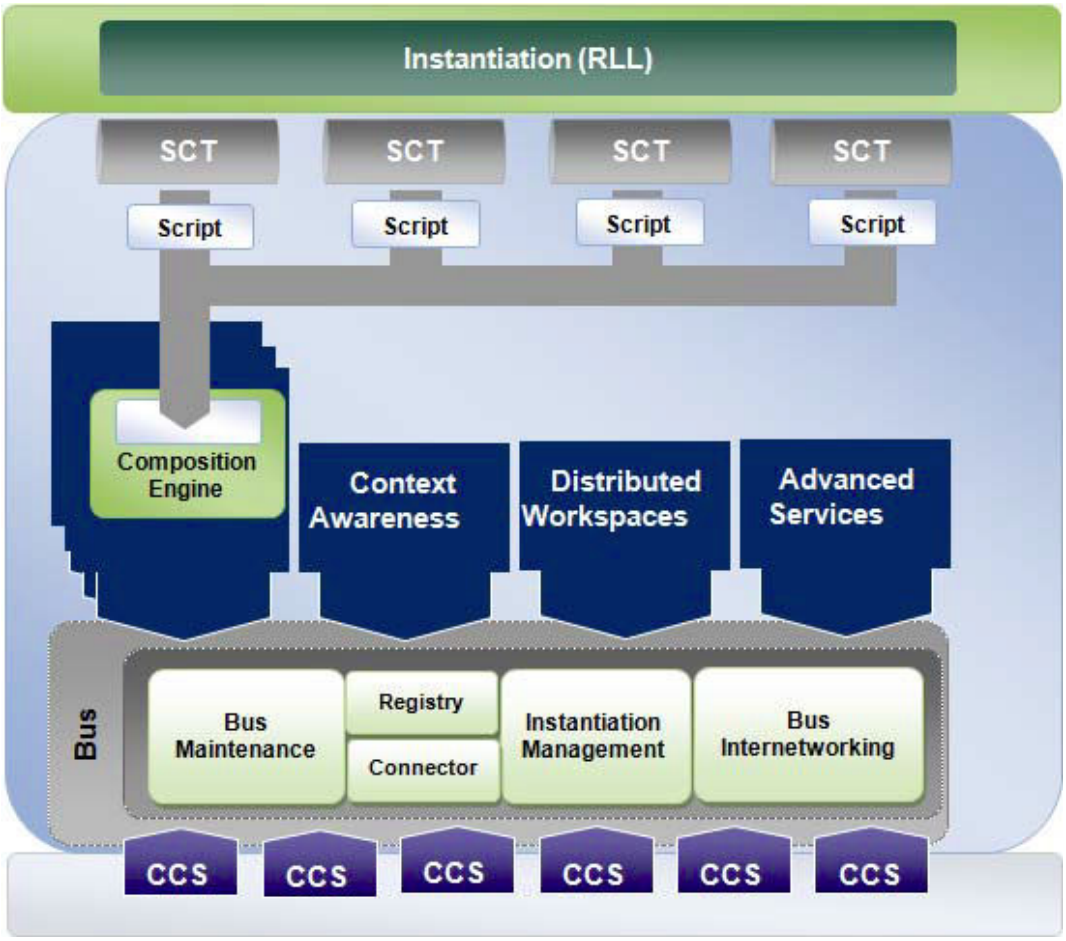
3. **Support better transfer of RTD results and innovation into everyday life of farmers, food industry and other rural communities** - As the analysis in Chapter I demonstrated, there is well visible progress worldwide in roll out of basic communication infrastructure. But the take up of new innovative rural solutions is not so fast and in many cases, there is a low transfer of RTD results and innovation into practice. To be able to react on future demands, the fast innovation transfer is necessary. It requires more parallel actions, like better interaction between support for RTD, innovation and implementation activities (in European scale Framework program and Leader activities for example), user demand on research priority, focus on long time of sustainability of founded research, but also support for training and awareness. Training of rural communities will be essential for adoption of new solutions and technologies. There is also necessary to stimulate open and public scientific debate about such controversial themes such as bio energy production or genetic modified production.
4. **To accelerate bottom up activities as a driver for local and regional development** – aBard and DG Agri studies recognised as the key success factors for development of rural regions local activities and existence of local champions. This could be:
    a. (local actors who are not interested in technology but take up the role for the greater good of the communities they live in,
    b. younger and higher educated people moving to the rural areas, who wanted to have the a level of services as in cities,
    c. local business with clear innovative and knowledge based growing strategy that needs an access and sharing of knowledge,
    d. people moving to a rural area and wishing to engage in e-enabled,
    e. people who have holiday homes in the rural area, that want similar broadband access similar to cities and other activities.
    f. Existence of such champions has the same influence as subsidies on local and regional development. The experience demonstrated that in almost all projects there were no strong bottom-up interests. In order to support this we have to increase the areas in which rural industries and citizens find social spaces and collaborative working environments supporting local networking and initiatives.
5. **Making rural regions as an attractive place to live, invest and work, promoting knowledge and innovation for growth and creating more and better jobs** - Abandonment of cultivated land has been increasing in many regions of the world. In several parts of Europe, the opposite trend exists with people moving back to countryside, but without returning to agriculture production. The number of people working in agriculture decreased in some countries to 2% of the country population. To attract people back to rural regions, it is necessary to improve infrastructure, possibilities of employment, culture, education, etc. It includes spatial planning, improvement of situation of local and regional SME industries with focus on agri-food industry but also on local production and tourism.
6. **Build new ICT model for sharing and use of knowledge in rural regions.** Currently we can recognise more shifts of technologies to web-based and mobile solutions, cloud computing, open access to context, social media, collaborative platforms and business intelligence. Building such solutions will not only help rural communities, but will open also new business opportunities for the local and regional ICT industry through development of

new applications and tools to support the European agri-food and rural sector. Participation of local ICT SMEs on development and implementation of local applications will play an important role in regional development.

3.2 ICT vision

3.2.1 c@r

Currently the new emergency concept in ICT was introduced by the Future Internet [23]. Such concept was already elaborated and tested in the c@r project [24], [25].



The schema describing the C@R architecture is from Christian Merz et al. / Reference Architecture for Collaborative Working Environments [25].

The architecture was described as:

- CCS – Collaborative Core Services implemented as reusable software;
- SCT – Software Collaboration Tools;
- OC - Orchestration Capabilities;
- LLA – Living Lab Applications cover end user interactions.

Currently, this concept is extended by more projects e.g. FI-WARE and COIN IP. FI-WARE is focused on architecture design, COIN IP on enterprise collaboration and interoperability services [26].

3.2.2 COIN IP

COIN IP was looking for a concept of Future Internet from the perspective of business collaboration and business interoperability. It defines three types of services:

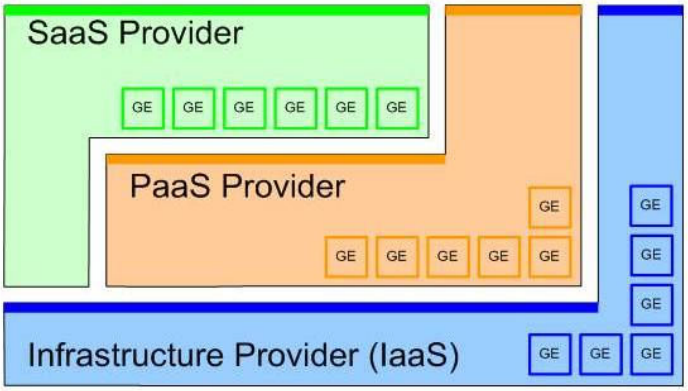
- Enterprise Collaboration Services supporting collaborative processes in supply chains, collaborative networks or business ecosystems;
- Enterprise Interoperability Services reducing incompatibilities among enterprises;
- Service Platform as integrating services for enterprise collaboration and enterprise interoperability based on semantically-enable Service Oriented Architectures (SSOA) [24], [25].

COIN IP provided a study of business models. It is working with the concept of SaaS-U (Service Utility) as specific business model. It expects that the utility paradigm will be used for offering services. Model expects that use-value and exchange-value are not identical and that in the future mainly added value services will be sold. The analysis also mentioned the possibility of domination of market by few organizations, like in real utilities. [30]

3.2.3 FI WARE

According to FI-WARE future internet includes:

- Cloud computing - There are three basic models of Cloud Computing
  - Infrastructure as a Service (IaaS): rating compute resources;
  - Platform as a Service (PaaS): use of a specific programming model and a standard set of technologies;
  - Software as a Service (SaaS): end-users are renting stacked Final Application; [23]
  - The XaaS stacked model [23].



- Internet of things – understand interconnection of physical object, living organism, person or concept interesting from the perspective of an application. [23].
- Data and content management - of data at large scale is going to be cornerstone in the development of intelligent, customized, personalized, context-aware and enriched application and services.
- Application Service Ecosystem includes reusable and commonly shared functional building blocks serving a multiplicity of usage areas across various sectors.
- Security - has to guarantee that the personal information provided by users will be processed in accordance with the user rights and requirements.
- Interface to networks and devices - has to guarantee access a variety of physical networks, contents, services, and information provided by a broad range of networks.

3.2.4 SmartAgrifood

This technological concept is now in the stage of design, but is expected, that this concept will dominate in the future. The results of FI-WARE are transferred into agri-food sector trough Smart AgriFood project. As a part of the Future Internet Public-Private Partnership (FI-PPP) program. This project focuses on three sub systems of the sector:

- smart farming, focussing on sensors and traceability;

- smart agri-logistics, focusing on real-time virtualisation, connectivity and logistics intelligence;
- smart food awareness, focussing on transparency of data and knowledge representation [38].

SmartAgrifood project defined next functions of the Future Internet for agri-food sector

- **Function 1**. The Internet is not limited to self-standing PCs -direct communication is possible between the machines, equipment, sensors, mobile phones, household refrigerators etc.
- **Function 2**. There is mobile equipment as data collector, data viewer (display) and information transmitter.
- **Function 3**. Quick and real-time exchange of large amount of data/video/3D information is possible.
- **Function 4**. Content based browsing - intelligent distribution and caching of content -each piece of information and each object gets an individual ID code. We need to specify properly what we want to know without knowing where to find it.
- **Function 5**. Services of customized information automatic integration of information on demand.
- **Function 6**. It is possible to positioning with higher accuracy for exact identification of objects, and controlling of the (agricultural) machines, equipment.
- **Function 7**. Cloud computing is able to handle tasks requiring high data processing, computing capacity. Users do not need to have their own infrastructure; it is available and accessible through the Internet at low cost and when necessary. Interworking is possible between local sub-systems and global system (cloud).
- **Function 8**. Higher privacy which guarantees the protection of personal data.
- **Function 9**. Global data warehousing and management capability is available (application for diseases, pesticides, fertilizers, foreign body, reference samples, etc.).
- **Function 10**. Ability to monitor meeting a set technical requirements and initiate automatic corrective actions and/or alarming system operators [39].

The SmartAgrifood project defines agri-food specific content to generic building blocks of FI-WARE Future Internet:

- “Cloud Hosting”: the Cloud Hosting concept is the basic enabler for providing scalable computation, software, data access and storage services. With a cloud, users can rent software as a service or only as an infrastructure (e.g. data storage), keeping investments for small companies low. Small software companies will be competitive, as the cloud provides the possibility to focus on the application development without the need to implement a full functional platform. This also reduces time to market for new developments.
- Data/Context Management: The Data and Context management implements facilities for transfer, conversion, storage, analysis and access of huge amount of data through the cloud. Further, instead of just processing data, the meaning of data is linked, allowing end-users to interpret data in certain context. This functional block will enable a manifold of applications, e.g. intelligent decision support systems for farming or logistics, video or image processing for surveillance of the product quality or the integration of food or product specific ontologies or vocabulary.
- Internet of Things Services Enablement: Instead of only connecting computers and servers, the Internet of Things (IoT) takes all physical objects into account and extends the capabilities of entities to process information autonomously, react proactively and context sensitive to their current environment. It will support the communication, resource management, data handling and process automation of sensors, RFID systems, or peer-to-peer machinery communication. It would support scenarios of e.g. online greenhouse management, remote machinery diagnostics or tracking of goods and their quality.
- The Applications/Services Ecosystem and Delivery Framework: These GEs will enable the creation, composition, delivery, monetization and use of applications and services on the

Future Internet. It also supports business aspects related to the service provisioning, such as offering, accounting, billing and SLAs. Through composition of components developed and provided by different parties, new services tailored to the needs of specific usage areas can be provided. It offers the potential for e.g. Farm Management Systems, virtual market places for goods and services (e.g. transportation, spraying), legal compliancy and quality certifications, advisory services (e.g. e-veterinarian) or discussion groups of stakeholders.

- Interface to Networks and Devices: A broad range of devices will be enabled to communicate in the Future Internet through any wireless or fixed physical network connection at any place. Users will have their working environment and their applications, independent of the device, the location, the service provider or local (legacy) infrastructure. This enabler ensures one of the top priority demands of the food chain users, having a seamless service anywhere and anytime with any device.
- Security: Common to any application is the strong requirement of privacy, integrity and security, providing the foundation to get acceptance and trust from all stakeholders. It handles aspects of encryption, data access policies, fraud- and intrusion detection and identity management. The success of a manifold of Future Internet scenarios will rely on a proper implementation of the security aspects, ensuring that data will be only accessible from an authorized set of stakeholders and for the agreed purpose [40].

3.2.5 Conclusion form IT innovation

The vision of the cloud will become a reality to overcome the problems of monopolies and opening possibilities for small and medium developers. Two aspects are important:

1. Interoperability and service oriented architecture, which allows easy replacement of one component or service by another one. This concept is already currently broadly used in geographic information systems.
2. Support for large scale utilisation of Open Sources [27], [28], [31]. Currently, Open Source generates business for companies which customise solution into final applications. Such web based solutions could generate profit for SMEs. For the future growth of the Open Source market, it is necessary to look on such models, which will attract producers of software to publish their systems as Open Source. It is also important to find for them sustainable business model. The goal is in principle not only to build communities, but also to open the chance to generate profit for primary producers of such systems and components.

We believe that the future solution will be in some way a convergence of current methods introduced by Future Internet, mainly interoperable cloud computing, with principles of Open Sources.

2.1 Standardisation trends (agriXchange)

A part of the agriXchange work was focused on the basic design of the generic integration framework for data exchange harmonization and interoperability based on selected use cases. The project works with two levels of use case descriptions. The first one is a “wide scope” use case description covering a whole domain specific procedure fulfilling the user needs for example fertilizing procedure from planning to execution, consisting of a chain of processes, actors and data exchange transactions. The “narrow scope” description serves as a metadata model of the interface, where the context of the data transaction of that specific interface is described shortly.

The agriXchange was focused on two aspects:

- the structure of the framework model serves information sharing and harmonization development of the data exchange, and
- the implementation of the practical model tool (aXTool) in the agriXchange platform have to be user-friendly.

The agriXchange Reference Framework design contains functionalities such as search, contribute, discussion and evaluation by user experience, and also a mechanism for quality management. The

design serves different interest groups with their focus on either wide scope use cases or narrow scoped interface solutions, and assists in interactions between the scopes [45].
From the user's point of view, the Reference Framework should serve four main functions: searching for existing solutions interlinked with any open (standardized) interface, contributing (to) existing solutions, discussion and evaluation of solutions and possibly polling of them. The Reference Framework tool should provide information in details that suit to user's demand in different phases of a system development process.

Classification of contributed information according to the agriXchange Reference Information Model (aXRIM) is a backbone for the generic integration framework and provides the foundation for the relevant functionalities of the aXTool, like relevant and efficient search functions. The main classes of aXRIM are Process, Actors, Communication protocol and Data. The aXRIM includes elements which concern Technical architecture and Technical communication infrastructure (Class: Communication protocol) and Organisational embedding (Class: Actors).

Users can be classified as developers, modellers and business users depending the scope of their interest. The users can represent specific groups of narrow interest areas or wider themes. When contributing, users follow a certain work flow through which the aXTool gives guidance. The quality maintenance requires the contributors to identify their name, organisation and community they represent, and the contact information. Also, collected user experience of already existing, by other contributors shared solutions, are utilised to describe the quality of a certain solution [41].
Wide scope use case descriptions serve development and optimizing of farming, food logistics and trading systems which capture several sub-systems, actors and stakeholders. Narrow scope interfaces focus on single data exchange interfaces and actors and processes around them, and level of information details is higher including technical details, standards and other implementation instructions. For this level, one of the most important factors in data exchange is sharing vocabularies. In many cases, each data exchange solution has its own specific vocabulary. To increase cost efficiency in constructing an interoperable system, harmonizing vocabularies is one of the most important matters. The aim of the information modelling of the three use cases is to give a high-level understanding of the content of the information to be exchange between the parties/actors involved. Gathering the data content from different use cases to the agriXchange collection gives a good ground for further analysis and harmonization of the vocabulary in the agri-food sector [42].

4 Strategic Research Agenda

What will be the RTD priority for next period? What needs to be done in the application domain? What are the future technological solutions? In accordance with the Cologne Declaration, we divide the research priorities in two groups:

- Application Research domain for Agriculture, Food, Rural development and Environment,
- ICT technologies for Agriculture, Food, Rural development and Environment.

4.1 Application Research domain for Agriculture, Food, Rural development and Environment

Currently, we recognise the following priorities for research domain for Agriculture, Food, Rural development and Environment:

- **Collaborative environments and trusted sharing of knowledge and supporting innovations in agri-food and rural areas, especially supporting food quality and security** - The concept of the trust centres has to represent an integrated approach to guarantee the security aspects for all participants in the future farm. There will be a growing importance of protection of privacy and IPR. Trust of information is one from the priorities for all rural communities. Pan European social networks have to support trust centres and enable such technologies as cloud applications and which will have to guarantee knowledge security. [11]
- **ICT applications for the complete traceability of production, products and services throughout a networked value chain including logistics** - to develop world-class network management solutions that facilitate communication and co-operation between networks of SMEs and large enterprises in the agri-food and rural development domains. These solutions will enable the management of food supply chains/networks, virtual and extended enterprises through collaboration and knowledge exchange. [11]
- **New generation of applications supporting better and more effective management of agriculture production and decision making in agriculture** - Future farm knowledge management systems have to support not only direct profitability of farms or environment protection, but also activities of individuals and groups allowing effective collaboration among groups in agri-food industry, consumers and wider communities, especially in rural domain. Having these considerations in mind, the proposed vision lays the foundation for meeting ambitious but achievable operational objectives that will definitively contribute to fulfil identified needs in the long run. [11]
- **ICT applications supporting the management of natural resources** - With better understanding of the environmental relations, the necessary valuation of ecological performances will become possible. Pilot projects and best practice samples will be the key to demonstrate for a wide auditorium the benefits of environmental caretaking. New model of payment of the different groups of beneficiaries have to be worked out (local, regional, national, continental and worldwide) as well as the best practice between today's "government owned" environment or "private owned with social responsibilities" has to be worked out [11]
- **ICT applications supporting agri-food logistic –** the focus has to be on the transportation and distribution of food, sharing online monitoring information from trucks during the transport of cargo, a flexible solution for on-demand dock reservation and an integrated freight and fleet management. In general, all the selected applications have the same

practical benefits as cost reduction, better coordination and better information for decision making, and the proactive control of processes leading to increasing efficiency and effectiveness [43].

- **ICT application supporting rural development and local businesses** - Rural businesses are usually small or medium size businesses according to the number of people they employ. Therefore, knowledge management and internal processes are different from large companies. Future knowledge systems have to be based on each community's own concepts of value, cultural heritage and a local vision of a preferred future. The objective is to develop human-centred reference models of sustainable rural life-styles that overcome social divisions and exclusion and include unique rural features and create new rural businesses and social infrastructures and attractive computer-based education.
- **ICT application for education and awareness** – Agriculture will require highly educated staff. There will be large shift from manual work to knowledge management. It will be necessary to provide effective knowledge transfer to as many people as possible, through a range of services and to meet the diverse knowledge and information needs of our customers and stakeholders and incorporating management practices and technologies on the home farm, supervised project work and discussion groups: linkages with higher level education institutions.
- **ICT applications reducing administrative burdens in rural areas** - Future ICT applications have to reduce the administrative burden of enterprises and citizens in rural areas by reducing the information elicitation process of businesses when they want to use a particular instance of some public service, or making more effective use of the resources. It has to include, adapt and deploy a web infrastructure combining semantic services with a collaborative training and networking approach, in the rural setting. Furthermore it should include e-Government services that regional public authorities already offer and support them by a rigorous and reusable service process analysis and modelling, and then deploy a semantic service that facilitates the disambiguation of the small businesses needs and requirements when trying to use the particular services. At the same time, the semantic service is complemented by a number of other web-based services that support the creation of communities of learning and practice in rural settings, thus facilitating the communication between the rural businesses with the regional public authorities. [29]

This list cannot be complete, but we would like to use this initial list as a basis for further discussion.

4.2 ICT technologies for Agriculture, Food, Rural development and Environment

The development of knowledge-based systems for the farming sector has to be supported by ICT focused on:

- **Future Internet and Internet of things including sensor technology, cloud computing and machine to machine communication** - Future Internet architectures must reflect the needs and specificity of rural communities. It has to be resilient, trustworthy and energy-efficient and designed to support open access and increasing heterogeneity of end-points. Networks should sustain a large number of devices, many orders of magnitude higher than the current Internet, handle large irregular information flows and be compatible with ultra-high capacity, end-to-end connectivity.
- **Service Oriented Architecture** as a key element of architectures for future knowledge management systems. Service Oriented Architectures have to provide methods for systems development and integration where systems group functionality around business processes and package these as interoperable services.
- **Methods of knowledge management** including aspects of interoperability. It is important to support the development of machine-readable legislation, guidelines and standards to integrate management information systems with policy tools. Major priorities for future

knowledge systems will be the integration and orchestration among services based on semantic integration of collaborative activities, including semantic compatibility for information and services, as well as ontologies for collaboration.

- **Semantic models, multilingualism, vocabularies and automatic translation –** The understanding of terms was recognised by AgriExchange and also by SmartAgrifood, as one from big problems for implementing interoperability. So the focus on common understanding and vocabularies is very extremely important. Other large problem is multilingualism. Rural citizens in many countries usually are able to speak and write only by their mother language. Language is a large barriers, methods of automatic translation has to be developed.
- **Management and accessibility of geospatial information** as a key information source for any decision. Geospatial information includes not only digital maps, ortophotos or satellite imagery, but also location services and sensors. Importance of geospatial information will become more and more important and its amount will rapidly grow with new sensors technologies. Effective methods of management, accessibility and analysis will be important. Open access to data will be important.
- **Open Source development** - Open Source development can bring a lot of advantages not only for research, but also for commercial community. Open source can help to users (private and public) and for all IT sector. The future will give more opportunity for open solutions and also for smaller flexible companies, which will be able to adopt their behaviour and react on new situation. Other important issue is large international cooperation of small companies and not only inside of one country.
- **New modelling methods** – new modelling methods will become in future more important. Their importance will be not only in application like precision farming, but also in long time planning and decision making. It will require growing computing capacity to introduce methods including linear programming or theory of game.
- **The power of social networks and social media** - The future development of technology has to be based on a broader utilisation of social networks and social media.

5 Recommendation for long time agriXchange sustainability

AgriXchange [44] was focused on future organizational aspects that have to guarantee long term sustainability of the AgriXchange activities:

- Founding a new, separate organization, that will take care of issues identified in the agriXchange project;
- Continuing under the roof of an existing organization within task forces, working groups etc.

Both options were analysed in this report. The focus was on analyses of past activities, maintenance and hosting of the web based platforms and on coordination activities. On the basis of the perfomed analysis, it seems not realistic to establish a new initiative. It is not only a question of financing, but it is also a question of building infrastructure, human resources etc. From this reason, we would like to recommend to move agriXchange under an umbrella of an existing organisation. It will increase the chances for financing of future activities. As a roofing organization, the European Federation for Information Technology in Agriculture (EFITA) would be suitable. There will be probably necessary some changes in the EFITA structure to make the direct participation easier for industries and individuals (not only trough national networks) and to make EFITA more operational. In principle, moving agriXchange initiative under the EFITA umbrella could be a win strategy and could help to both initiatives.

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