SmartAgriFood

ICT Induced Innovation

Input for Review Feedback European Commission

WP 600 and GM5

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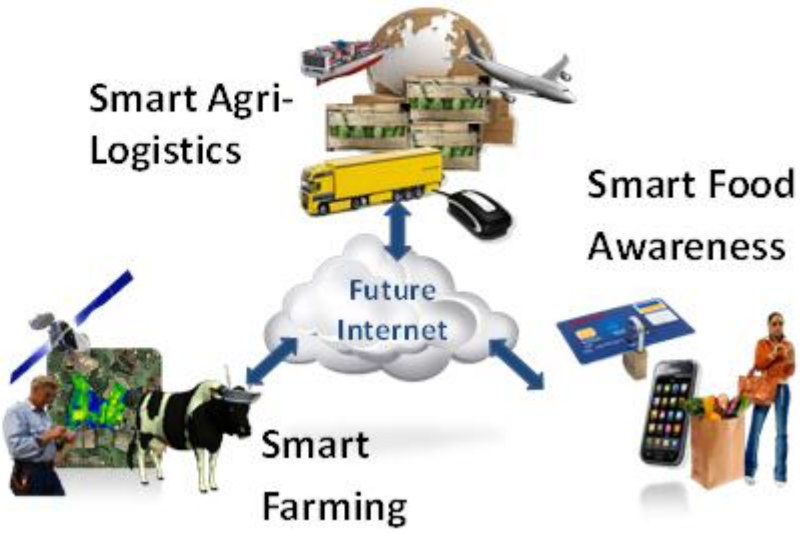
The SmartAgriFood Project

The SmartAgriFood project is funded in the scope of the Future Internet Public Private Partnership Programme (FI-PPP), as part of the 7th Framework Programme of the European Commission. The key objective is to elaborate requirements that shall be fulfilled by a "Future Internet" to drastically improve the production and delivery of safe & healthy food.

Project Summary

SmartAgriFood aims to boost application & use of Future Internet ICTs in agri-food sector by:

- Identifying and describing technical, functional and non-functional Future Internet specifications for experimentation in smart agri-food production as a whole system and in particular for smart farming, smart agri-logistics & smart food awareness,
- Identifying and developing smart agri-food-specific capabilities and conceptual prototypes, demonstrating critical technological solutions including the feasibility to further develop them in large scale experimentation and validation,
- Identifying and describing existing experimentation structures and start user community building, resulting in an implementation plan for the next phase in the framework of the FI PPP programme.



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Dissemination Level

PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Change History

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001	Creation of the document	01.05.2012
002	Refinement of the main contents	06.05.2012

Abbreviations

D	Deliverable
FI	Future Internet
FI-PPP	Future Internet Public Private Partnership
ICT	Information and Communication Technology
SME	Small and Medium Sized Enterprise

Table of Contents

Note for the reader

Readers who are mainly interested in innovation in the agri-food chain with ICT can directly read the chapters 5, 6 and 7.

The preceding chapters explain and argue, based on economic and transition theory, why ICT induced innovation is relevant in the next years and might lead to big changes in the food chain.

1 Introduction

ICT is a big driver for innovation. After the successful instalment of computers in many parts of society in the last 25 years of the last age, the internet started to connect those computers in the 1990s and recently new forms of collaboration in social media have grabbed the attention. Where until now working processes inside organisations have been transformed and (long distance) specialisation between firms has increased, it is likely that in the coming years new forms of collaboration between organisations (businesses, consumers, government) will take off. At the same time hardware, like sensor technology and RFID chips but also including computer power and transmission capacity, is still getting cheaper and leads to new options, like the Internet of Things (the idea that not only computers could be networked, but a lot of other things that have a chip attached, from cows to containers and refrigerators). Many of these technical trends are coming together in the Future Internet concept. Within this FI-framework we are interested in the domain of AgriFood. This memo, written on request of the reviewers of the Smart AgriFood project, explores which types of innovation might be induced by these ICT developments.

The memo is organised as follows. In the next session we argue that the current phase in the economy signals that big changes are happening, with ICT as a big driver. This is based on the long-wave theory in economics. We then turn into transition theory that argues that big changes in society happen if current regimes break down due to pressure from general trends (the 'landscape level') using options that have been successful already at a smaller scale in 'niches'. In this framework we discuss a number of important general trends in the food chain and identify the use of ICT in some niches that seem to be relevant for the development of the future internet. Based on this we speculate what the regime-change due to the ICT development might look like. This is clearly not hard science but more a Jules Verne type of activity. More in detail foresight studies using e.g. scenario analysis, might be attractive and it asks Steve-Jobs –like visionaries to create innovations that rave markets. That also makes it impossible at this stage to do a cost/benefit analysis for such societal investments. Nevertheless we think that such an envisioning is useful to guide discussions in the EU's Future Internet programme, regarding agri-food.

2 The current economic situation: institutional innovation needed[1]

Over the last two years the economic outlook has deteriorated strongly. The booming economy of the last decade has turned into a severe stagnation. The financial and sovereign debt crisis has led to characterisations by leading European politicians as 'the biggest crisis in the life of the Euro" and even "in the existence of the EU" or "since the depression".

That these claims are not too much exaggerated can be shown by figure 1 that is based on historic-economic analysis in long term business cycles by Carlota Perez (2002). This theory states that economic development since the first industrial revolution is driven by technological-economic cycles (waves) that take about 50-60 years to complete. These waves start with a new technology that is not necessarily a new invention (the car existed for 25 years as a toy for the rich before Henry Ford made it cheap to produce) but starts to become cheaper and cheaper (the microchip that Gordon Moore invented in 1971 still doubles in capacity / halves in price every 18 months) at such a startling speed that it has big effects on how we can organise society.

This breakthrough typically happens in a period of standstill and capital searching for new options. After this irruption phase in which technology is leading, investors and society becomes too enthusiastic. There is overinvestment

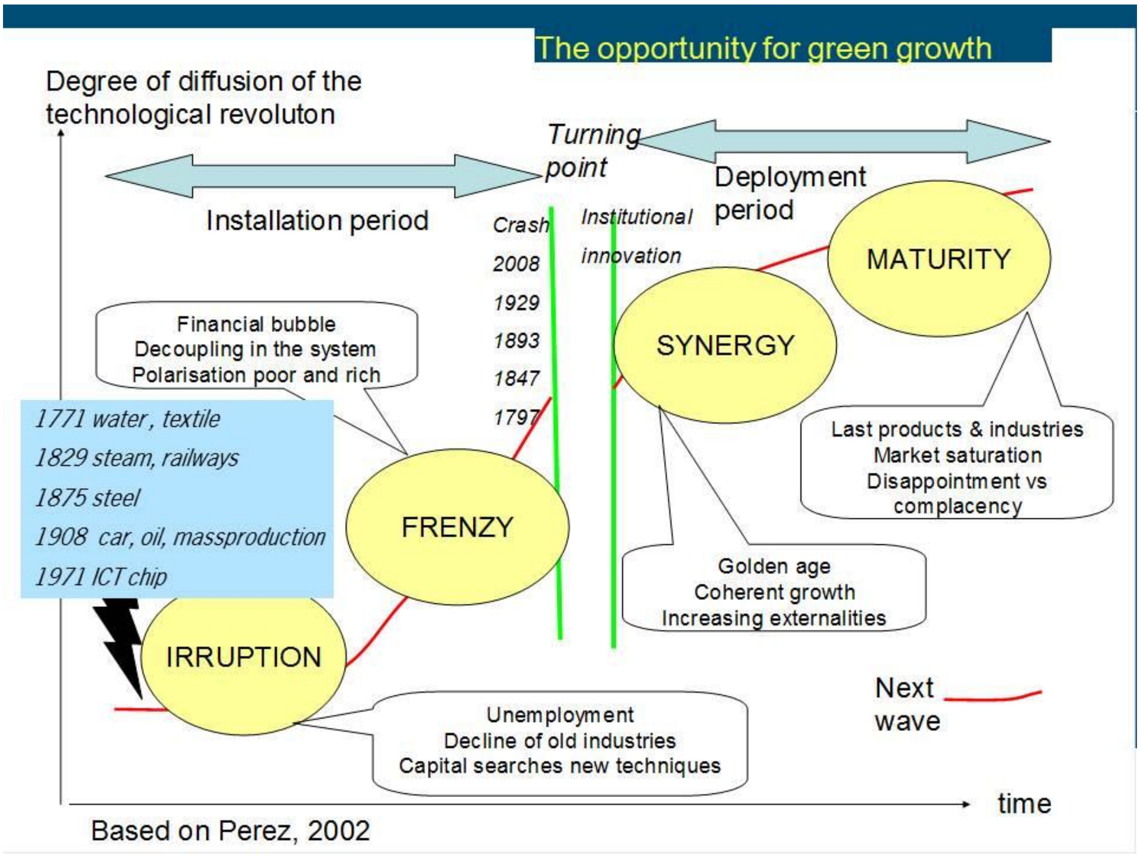
[1] The text of this section has partly been taken from a text that the author has written for the report of the SCAR (EU's Standing Committee on Agricultural Research): Agricultural Knowledge and Innovation Systems in Transition, Brussels, 2012

('new economy', old paradigms for prudent investment are declared non-relevant as this time is different) resulting in a financial bubble. That leads to a crash.

According to this theory we are now in the 5th wave (or industrial revolution) with ICT as key technology and the current financial crisis (that started with the Nasdaq crisis in 2000 but only really spilled over to the real economy with the default of Lehmann Brothers in 2008) can be interpreted as the mid-life crisis of this ICT wave.

Historically such a period is a turning point that calls for (acceptance of) institutional innovation. New ways of working are accepted. Failures of the previous period are corrected and rules are put in place to make new technologies work in situations (older industries) that until now had not innovated with the new technology. Such a change can lead to an era of coherent growth, as for example happened in the 1950s. After that phase the technology has more and more walked its course and not many profitable opportunities are left. Negative externalities (like the pollution we are confronted with from the last stage of the previous wave) start to dominate and a certain level of disappointment with the technology can be sensed.

Figure 1 Long wave theory



Source: Perez, 2002; see also Perez, 2010; Poppe, 2009

This narrative makes clear why the current economic situation is more than a normal hiccup in the economic machine, but a major crisis. It also makes clear why there are calls for institutional innovation, to renew our economic system and reduce the externalities of the previous wave. The OECD labels this "green growth". The EU has chosen the mantra "smart, sustainable and inclusive growth" that echoes a profit-planet-people approach.

Such institutional changes are in line with Williamson's contribution to the framework of New Institutional Economics (NIE). Institutional changes are needed to make the new technologies fully profitable, especially in older industries. Williamson showed (figure 2) that decisions of firms and consumers based on costs and benefits are influenced by transaction costs and property-rights. And those are based in social theory. These change only slowly: Williamson indicates that property rights are stable over a period of 10 to 100 years. The average of that is by coincidence (or not?) 55 years, the average size of the Kondratieff business cycle.

Property rights design the institutional environment in which people live and work. If the government monopolizes television as broadcasting technology make channels scarce, you cannot start a commercial television program or broadcast a commercial. And that all changes if broadcasting technology makes channels broadly available. If there is no intellectual property right defined on GMO seeds, you cannot commercially develop them. Property rights and technology determines the transaction costs that people and businesses face in exchanging goods and services. Low transaction costs lead to market based solutions: it is attractive to outsource activities to specialists. High transaction costs leads to organisations where the activity is done internally, to prevent even higher transaction costs in a market situation.

Williamson's scheme makes clear why institutional change is much more difficult than techno-economical change. Social norms and property rights are much more rigid. That has the positive effect that it reduces uncertainty in the society and makes e.g. investments possible. But it makes change in a transition more difficult. But from time to time they do change. New property rights are set (e.g. light pollution by glasshouses lead to complaints and a 'right' on darkness and investments to screen outgoing light) and social norms develop (e.g. a religious ban interest leads to alternatives for house mortgages which in a certain way weakens the social norm).

Figure 2 **Four levels of institutions**

Level	Period of change (years)	Core element
1 Social embeddedness	100 to 1000	Informal rules of the game – e.g. customs, traditions, norms, prevailing notions, preferences and ideologies
2 Institutional environment (property rights)	10 to 100	Formal rules of the game – e.g. policy, laws, regulations and the issuing of rules on ownership
3 Institutions of governance (transaction costs)	1 to 10	How the game is played – e.g. government, firm and club/self-organisation
4 Incentives and motives	Continous	Stakes of the game – self-interest and shared ideals

Source: Williamson, 2000

Concerning agriculture and food the long wave theory makes clear that ICT could be a major driver in the few years in this older industry. If drones are flying over Afghanistan, steered from faraway airbases, and metro line 1 in Paris does not need drivers anymore, one wonders how long it will take before we have unmanned tractors. Actually the Austrian company Fendt won a gold medal with a prototype on the 2011 Agritechnica in Hannover (that is controlled by the chauffeured tractor nearby which behaviour it mimics) and at a discussion on innovation under the Polish presidency a leading developer of the John Deere company explained that tractors already can do without a driver very well, but that liability considerations (institutional environment!) and the machines behind the tractor makes one necessary for the moment. This example is not given to predict but to show that in our economic system big transitions are going on, not unlike those in the 1930s and 1950s, that will have consequences for farming and food systems.

3 Multi-level perspective[2]

Transition and transition management have become major topics in scientific research and policy practice over the last years. Transitions are defined as a gradual process of change which transforms the structural character of a societal domain. Basic assumption underlying the transition model is the diagnosis that societal problems are not caused by clearly identifiable actors or factors but by failures of a systemic nature. Transitions are linked to system innovations, which are much broader than just technological innovations (because the current societal regime is supposed to change), and much more radical than incremental system improvements (because the change involved is a transformation of the system).

Transitions are defined as a gradual continuous process of change where the structural character of a society (or complex subsystems of society) is transformed. The co-evolution of a set of slow changes forms the undercurrent for a fundamental change. Transition processes involve multiple actors within a societal subsystem and fundamentally change both the structure of the system and the relations between the actors. Historical examples include transport transitions from sail to steam ships or from horse to car, and the energy transition from coal to oil and gas. Transitions are not a linear processes, but involve a shift in the system from one dynamic equilibrium to another equilibrium. Borrowed from socio-technical systems literature, a distinction is made in transition literature between micro, meso and macro levels, respectively referred to as niches, regimes and landscapes:

- at the macro-level the landscape is determined by slow changes in material infrastructure, political culture and coalitions, social values, worldviews and paradigms, the macro economy, demography and the natural environment.
- operating at the meso-level are the social norms, interests, rules and belief systems that underlie companies', organisations' and institutions' strategies and political institutions' policies. This level is called the regime level.
- acting on the micro-level are individual actors, technologies and local practices – the niche level.

At the niche level, variations and deviations from the existing regime can occur (e.g. new technologies or social practices). The socio-technical regime often acts as an inhibiting factor in the early stages of transition, reducing variety and deviations, but it can transform into an enabling factor when a new socio-technical regime is forming and gaining momentum. The landscape factors guide the flow of transitions but remain relatively unaffected themselves. Figure 3 represents this process in more detail.

This figure illustrates the view that transitions involve the disintegration of an existing ongoing socio-technical regime, seen as a configuration of industry, markets, policy, technology, science and culture. Niche-innovations break into the existing regime, whose disintegration allows for the emergence of a new configuration of elements, which is then stabilized into a new regime.

In the next section we use the idea that the current economic situation is one of institutional change with ICT as a driver and the multi-level transition perspective as a basis to identify relevant trends.

[2] The text of this section has been based on a paper by A. Dewulf, C.J.A.M. Termeer, R. Werkman, G. Breeman and K.J. Poppe: "Transition management for sustainability: towards a multiple theory approach" in K.J. Poppe, C. Termeer and M. Slingerland: Transitions towards sustainable agriculture and food chains in peri-urban areas, Wageningen Academic Publishers, 2009. See that paper for the references to the literature.

Figure 3 **Multi-level perspective in transitions**

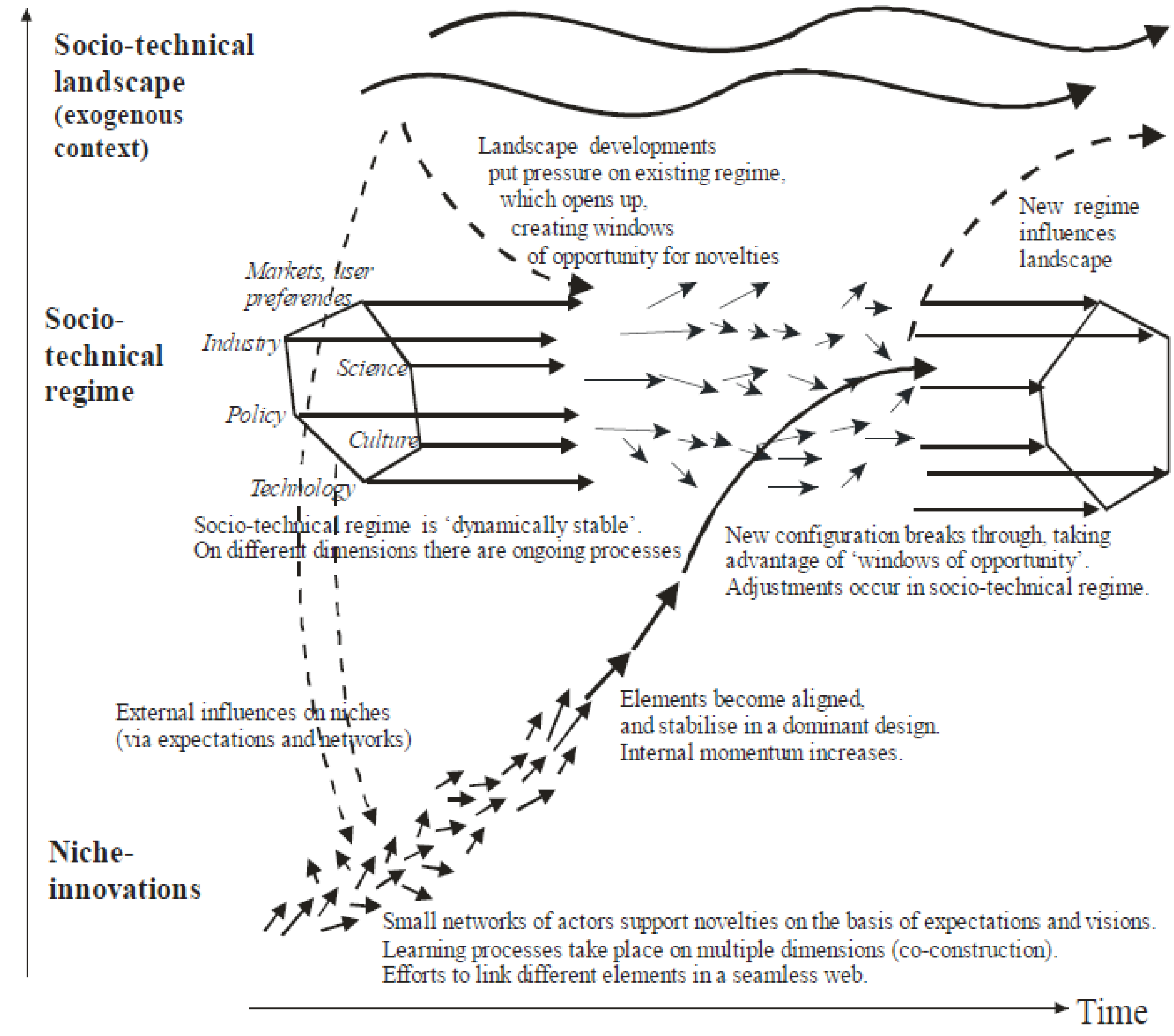


Figure 1: Multi-level perspective on transitions (adapted from Geels, 2002: 1263)

Source: Geels, 2002 as cited in Dewulf et al, 2009

4 Trends at the landscape level

There are a number of macro-trends that put pressure on how the agri-food sector is currently operating and that makes 'business as usual' an unlikely scenario:

- First of all there is the economic crisis that puts innovation high on the agenda of companies and the government. It also forces organisations and people to take more risks and to adapt. It leads to discussion on and changes in the institutional environment like the flexibility in labour markets, transparency of government (and open data), governance of the financial system and availability of finance, etc. A good example in farming is that in the proposed new Common Agricultural Policy innovation will be an important aspect (via the European Innovation Partnership for Productivity and Sustainable Agriculture that links the CAP with Horizon2020).

- The technical developments in ICT as discussed in the introduction of this paper: cheaper, more capacity, easier to connect, more user-friendly.
- An economic crisis is also a crisis of values. There is an increased interest in local as opposite from global that dominated the last decennia. Food has always been a tool for user to profile themselves in a social environment, but in the last decade food culture has clearly grown in importance. Sustainability aspects are much discussed, by chefs as well as large consumer segments and ngo's. The consumer market has become more heterogeneous. It is interesting to see that higher priced, more sustainable food is not suffering disproportionately from the crisis. This suggests that the drive to make our food and especially farming more sustainable, via the market or government policies, will continue.
- Demographical developments suggest that labour markets will be scarce in the coming years as a large proportion of the work force (the so-called baby boom generation) will retire. The unemployment due to the economic crisis might mitigate this, but there are big mismatches between demand and supply in the labour market regarding skills and location. Scarcity in the labour market will promote the use of ICT. Robotics comes to mind first, but the effect is bigger. Where a lot of blue collar (manual) labour is already mechanised and farm labour has left, the remaining labour are white collar activities, from sales and advice to management. This holds e.g. for farming as well as for the food processing industry. This gives a big incentive to increase size, as costs can be allocated to more products: a farmer and a processing industry can make the contracts for 1000 ton potatoes with the same cost as for 100 tons. And bigger farms and firms depend on professional management systems, less on informal methods of working.
- Not only consumers but also the farm sector becomes more heterogeneous. Liberalisation in the CAP gives farmers more freedom as well a pressure to choose their own strategy: bigger (economies of scale), better (more output with less inputs), different (alternative food systems, multi-functional farming), elsewhere (moving or starting a second holding in another location or even another country), or part-time (pluri-activity). On the broadest measure there are 13.7 million holdings in the EU-27. Nearly half of them (47%) are too small to be of any significance for food production other than self-subsistence. These farms[3] have 1.6% of production, but 23% of the agricultural work force is associated with these holdings. The real numbers are probably even higher as in some member states such farms are not counted as farms. Some of these farms are residential life-style farms that have (large) incomes from non-farming activities or pensions, most of them are very poor peasant holdings in eastern Europe. Of the remaining group of 7.31 million holdings, a large part is also very small and contributing only marginally to food production. As (labour saving) technology develops much faster than farms restructure (farms that are too small to be viable mainly disappear at the moment the farmers retire and children have voted with their feet) this situation is inherent to the sector. The EU labels about 5.4 million farms[4] (39% of the total number of holdings) as commercial due to their size and the fact they are responsible for over 90% of the production. Analysis of FADN data show that about 20% of the labour units (and that is even less farms) of this group of 5.4 million generates about 60% of the value added[5]. That suggest that less than 3 million holdings in the EU-27 are responsible for three quarter of the production and that this is the main target group to increase productivity and sustainability. It also suggests that on another 11 million holdings the challenges are more linked to social issues such as low income, poverty, hidden unemployment, lack of inclusiveness in society etc. It should be noted that the second group also includes very innovative farms with new farming systems such as services for nature management or health care, or have an income from farm shops or food processing, and is therefore a breeding place for innovation, but these are small numbers in most regions, still not well captured in standard statistics. This shows the heterogeneity and polarisation in farming and also partly explains why many farmers face problems to cope with the market prices that the most efficient farmers can tolerate. With heterogeneous consumers and heterogeneous farm systems it becomes attractive to search for methods

3 Technically: holdings smaller than 1 European Size Unit, Eurostat 2007 data

4 Technically: the field of survey of the Farm Accountancy Data Network, 2007 report

5 Source: FADN 2011 report, graph 1.14

to match those segments, also for a food processing industry and retail that is characterised by scale increase to benefit from efficiencies in the large European market.

- Related to that matching of consumer and farming segments the 3 million holdings that realise the bulk of food production are increasingly closely tight to the food chain and the innovation processes in the input and output industry. Their partners in the food chain are becoming bigger and bigger, to realise economies of scale and be an attractive partner or countervailing power to the large international retail chains and their buying desks. Local cooperatives have made way for larger transnational cooperatives, and that trend will continue in the next years – compared to a market such as the US the European retail and food processing firms are still relatively small. In this process integration of farming in the food chain via contracts and quality assurance schemes like BRC and GlobalGap will increase. As agricultural processes become more programmable (and are less dependent on unpredictable natural events), as investments are less general in nature (like a tractor) but become more tied to specific products (such as know-how on how to grow organic broccoli) and marketing is a joint effort of a producer group and a retail chain (such as with some new apple cultivars), more complex organisational forms appear, as relying on the spot market would be a big business risk for the parties in the food chain.

It are these trends (and perhaps some others like energy prices) that put a certain pressure and shape the current way of working of many actors in the food chain. They have the potential to increase the uptake of ICT in the agri-food chain in a dramatic way and lead to system-innovations. In the next section we look to what type of interesting ICT use is bubbling under the current regime and could be more dominant in the future.

5 Niches with ICT

Where the previous section focussed on some major current trends and uncertainties, this section looks to interesting niches where ICT plays an important role in the agri-food chain and that have the potential to become a much more mainstream way of working.

In the farm sector the use of ICT technology has increased strongly of the last decade:

- In (arable) farming the use of precision agriculture techniques has been introduced successfully in a number of European regions. Based on satellite location data tractors can be very precisely located. This makes it possible to increase labour productivity by making machines bigger (a 24 meter broad spraying machine must be driven by such technology to keep a tractor on a precisely right track, otherwise the arms of the spraying machine move too much), and by precise application of pesticides and fertilizers (also reducing pollution). Combining remote sensing growing data and farm data on crop interventions (and ex-post yields) lead to better decision making. But data are still hardly shared with advisors or the processing industry, analysed by intelligent software or combined in regional analysis and advise.
- Glasshouse horticulture has more control over its production climate than open air activities and glasshouses have become wired with sensors and computers to steer the production process in an optimal way. Especially around mega-cities with a poorly structured agriculture and bad logistics there is a lot of attention to agricultural business complexes, and some (not yet commercial) experiments take this to the limit in 'vertical farming', like the Dutch experiment Plantlab (see http://www.plantlab.nl/4.0/).
- In dairy farming milking robots have been introduced successfully on family farms in North Western Europe where labour is expensive and farmers are highly educated. The use of sensor technology is increasing: cows tend to get measured with sensors as intensely as sport athletes, as sensor data predict for instance much better diseases or the optimal time for insemination than the human eye.

In agri-logistics tracing and tracking has become standard. The food scares (dioxine crisis, BSE) have stimulated that development, also via European law. In some cases this had led to advanced systems that include the consumer stage. The basis of this is the unique ear tag number assigned to the animal after it is born. Its complete history is linked to this number. At slaughtering, the ear number is scanned and data are combined (e.g. with an RFID chip) with the hook in the slaughter line. From their quality data as fat covering and weight is added. At the time the carcass is divided, data from the hook is linked to a crate. During packing, the label with relevant data is printed out and packed with the meat. This makes it possible to trace from the point of sale of the meat to the individual animal at the farm (see a video that Finnish students in our project made in Germany: http://www.youtube.com/watch?v=pTw4V2EHgAg). RFID technology is seen as very useful for tracking and tracing[6].

Data from the food chain can be added to products. Barcodes are already used to provide consumers information on the components of a products, see for instance the German site Das-ist-Drin (http://das-ist-drin.de/). Such websites can also help consumers to select such products (see http://www.goodguide.com/#) or see where you can buy them as on the FairTradeFinder (http://bynd.com/2011/11/07/fairtradefinder/).

Tracing and tracking of products is not only relevant for traceability in case of quality problems but has also helped to improve transport planning, and efficiency by concepts as just-in-time and cross-docking in retail distribution centres. In the consumer market such techniques are known from tracing parcels with companies like DHL. The delivery systems have helped farmers to set up web shops, inspired by the Amazon.com model. The wine sector has many examples, others are in chocolate or in Mediterranean products (see for instance LaVialla from Chianti that sells among others in the Netherlands: http://www.lavialla.it/uk/home_uk.asp). It can lead to tailored products like in MyMuesli (http://ch.mymuesli.com/).

Retailers are using apps on smart phones to support consumers and to increase brand loyalty. Such apps help to create shopping lists and optimize shopping routes in the store. Tesco has taken the idea one step further in an experiment in South Korea where the supermarket comes to you in a virtual form, projected on the wall of the metro station, as alternative to an online shopping service (see http://www.youtube.com/watch?v=fGaVFRzTTP4). In the Netherlands Ahold recently bought the online (book and music) retailer Bol.com, which can be interpreted as a clear signal that retail is also moving online.

This list of examples show that several actors in the food chain have already advanced use of ICT and are experimenting with new developments. Where many of the ICT use in the past was within the factory or the retail outlet (and now also on the farm or in the glasshouse), newer developments are based on using ICT in the interaction between partners like in tracing and tracking or on line shopping.

It is based on these niche experiments and the trends at the macro ('landscape') level that we think that ICT will revolutionize the food chain in the coming years, based on the exchange of data between partners.

6 Regime change

At the regime level the different actors in the food supply networks have their own business models – and problems. Retailers have hard times and focus on brand loyalty: their main worry is to get the costumer back in one of its stores in the next days or week. Competition between retail formats is strong, and increasingly there is competition with food service and on line retailers. Supermarkets were introduced 50 years ago as labour costs became too high to provide individual service through a shop assistant and the higher labour income created demand for more choice. But time-stressed consumers are not necessarily interested in picking large volume products from shelves on a Friday evening. This explains the interest in ICT-related shopping experiences.

Food processors have to cope with the increased power of the large retailers and their buying desks. Not all brands are A-brands. Internationalisation (for economies of scale) and consumer-oriented product innovation are key challenges. Data from input suppliers, including data on sustainability can play a role in that.

Logistic solution providers that organise the transport in the food chain try to cope with the pressure on margins by developing service concepts, so that the business partners can concentrate on their core process. That lead to data intensive collaborations.

[6] see an EU FP7 project: http://www.youtube.com/watch?v=lmvHohm3SYA&annotation_id=annotation_236581&src_vid=rCgbmN8AWXM&feature=iv

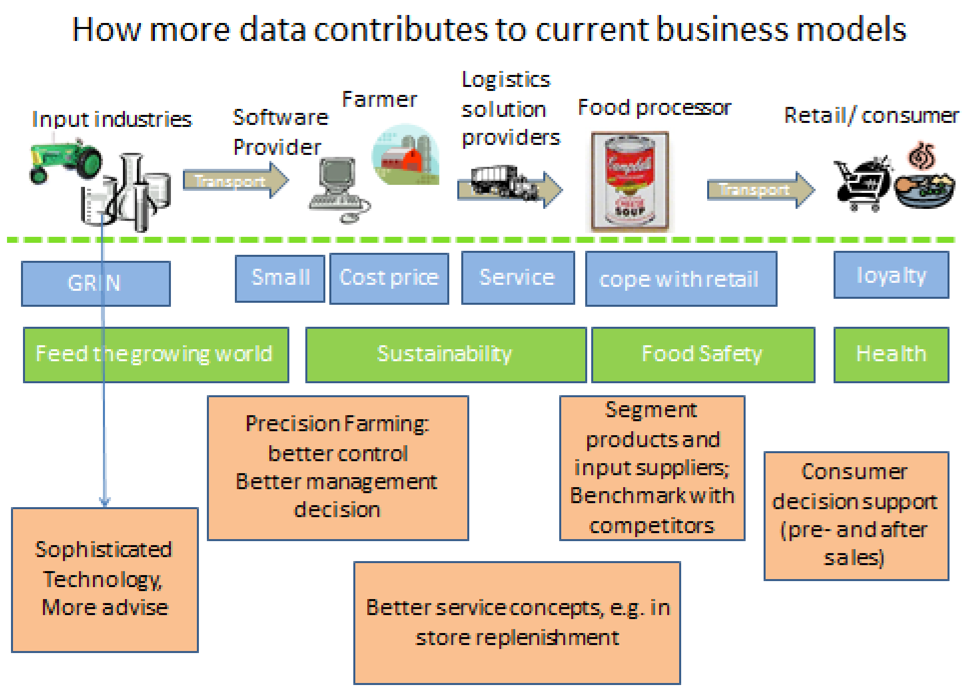
Farms are small businesses that mostly try to decrease their cost price, either by more technology or by increasing their size, and often a combination. As we have seen above they are increasingly data intensive and use software to collect data and make this available to the food processors for tracing and tracking as well as to the government (for instance the use of geographical information systems has been promoted by the Common Agricultural Policy). In this they are supported by small software companies, very often working on a regional scale that understand the farm language and provide hardware and software maintenance services.

Input industries are often work worldwide. They are R&D intensive and deal with new technologies as Genetics, Robotics, Informatics and Nanotechnology (GRIN). The challenge to feed 9 billion people in 2050 with restricted resources and less pollution is a major challenge - and business opportunity for these companies.

That leads us to the public challenges that are relevant in the food chain, lead to government intervention and are also business opportunities. Besides the challenge to feed the world, there is the sustainability issue that by nature and due to the characteristics of the sector is especially an issue in farming and transport. Food safety is another issue as well as the relation between food and health (e.g. obesity).

Figure 4 shows how more data and ICT contributes to the development of the business models discussed and the relevant public challenges: more advise bundled with technology, precision farming, better service concepts in logistics, segmentation in the food industry to cope with heterogeneity in farming and with consumers and consumer decision support.

Figure 4 The need for more data in food chains



Source: this project

The core idea of the FI-project Smart AgriFood is to bring these developments one step further by organising data exchange in the chain and to show how this leads to innovative concepts. A number of common pool resources are needed in the food chain to get this data exchange at a higher level of professionalization and move it away from the current paperwork.

For the SAF smart farming system we have designed a service oriented architecture that allows the integration and support of a plethora of services that can be developed by any stakeholder. This is expected to create a new market place like Google's "play store" or Apple's App Store market. This will allow end users (e.g., farmer's) to use sophisticated services at very low prices, like this is currently the case for mobile applications. Transparent and easy to understand charging and accounting mechanisms will also be used. The system is designed in a way not to lose all collected raw data (e.g., sensors' values, selling prices, used chemicals) when moving from one system provider to another. This is achieved by separating the raw data from data that are the outcome of raw data processing from different services. A farmer's perspective of the resulting system is given in Figure 5.

Figure 5 **An arable farmer in 2020**

March 2020, a field in The Netherlands

The morning mist soaks into thick shreds across the country, above the sun rises and turns the horizon red. From the fog a soft humming sound, two tractors emerge. Wasn't it this field where that strange vehicle drove around? When he spots me, the driver of the second tractor steps out, but where is the driver of the first tractor? There is none, says the driver. I operate both machines. How do you do that? That strange vehicle that you last saw here, has mapped the whole field, including the ditches but also soil composition. That map is now in the board computer of the two tractors. The first tractor exactly follows the pre-programmed lines and carries out a soil cultivation, based on soil composition. My tractor automatically follows the same lines. Based on soil composition the sowing machine adjusts the distance, quantity and variety of sugar beet seed that I am sowing. Ok, so you sow several kinds of beets, at different distances? Yes!

Two weeks later

The same field. An unmanned small tractor rides with a high speed along the same invisible straight lines. A hoe eliminates with a high precision almost every weed in the field. But there is nothing to see of the sown plants! Yes, here and there a germ, but that's not important, it also knows the tractor tracks. Therefore we can easily hoe the weeds very close to the plants. Just like the robot that I am about to put on this field to remove the small weeds that were left. This gives a huge saving on chemicals and labour unlike in earlier days where we had to spray the full field with a heavy tractor. That was expensive and environmentally polluting so this is good for the profit and the environment. Within a few weeks the fertilizing machine will come and follow the same lines again and through a map in the board computer it knows exactly where and what to put different types of fertilizer for optimal growth of the plants. That map was generated by the computer at the office and it contains all data and requirements of customers and the government. Sensors are checking the crop and if necessary evoke necessary corrections. Again, the plants just get enough nutrients to grow optimally and nothing is spoiled to the environment. Wow, amazing! Come, I'll show you how it works in the office. Don't you have to stay with your tractor? Oh no, it knows what it is doing.

At the office with a good old-fashioned cup of coffee

As a farmer we still have to make decisions, but we now have a wealth of resources to make the right choices. From the computer we exactly know what the customer demands on the product and how we should translate that into a treatment on the field. We have a direct connection to the customer. This allows us to respond much better to the demands of the market. Basis on the collected data (soil maps, yield maps from last year, crop scan, work already performed, etc.) the computer is empowered, supporting us in the decisions. From here we make work assignments for the various machines. Work orders? Yes, those maps that you saw on the screen in the tractor, that indicated the variety and in what quantity to sow, the amount of plant nutrients, etc.

After the execution of the work, the measured data is automatically returned from the machine to the office. The driver eventually can add some of his own observations and other work he has done. This is the basis for subsequent work. But it is also the basis for research in the university, which feeds this data to the computer models that are further improved. And all those stacks of forms that were previously send? What do you mean? Well, the government forms indicating what you've grown and other forms about the use of manure and all the different forms the customers wants for each product, etc.? Oh that, that has long been abolished. Not that we don't provide the customer and the government with no information, on the contrary they get even more than before. But that goes automatically now. Every demander of information has access to a specific set of our data that are stored somewhere in a data centre, I thought somewhere in Finland. Of course, this is surrounded by strict security and privacy rules.

So we deliver a much better product quality, tailored to the needs of our customers. We provide all necessary data for their subsequent processing operations. Actually, we provide specialized, knowledge-intensive products for specific markets or operations with high added value. Oh yes, food safety is no issues anymore; it is highly guaranteed through these modern techniques and strict procedures. And by automatic data storage traceability is also perfectly organized.

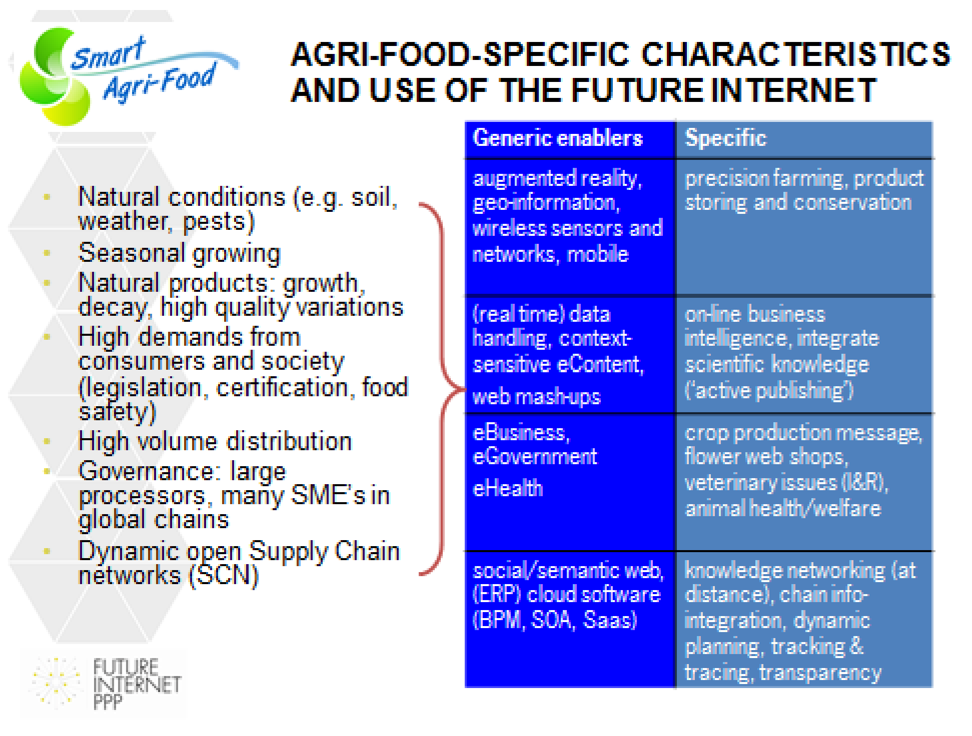
Source: Sjaak Wolfert: KodA project

Now that most companies have been able to integrate data in their internal systems, it seems to become time to that in supply chain networks. For the moment, lacking a more sexy name, we could label such a tool as an ABCDEF – an Agri-Business Collaboration and Data Exchange Facility.[7]

Such facilities or platforms would make it possible to move data seamlessly from one partner in the food chain to another. This also makes it possible to create new services. In Agri-logistics we show how data exchange between growers of pot plants, service providers and retail stores (forth and back) would lead to intelligent dynamic planning that decreases costs and waste and improves product quality. We also show how RFID technology in vegetable logistics improves operations and tracing and tracking. In Food Awareness we demonstrate how the data from the food chain could be delivered to the consumer and matched with her own shopping profile based on health and sustainability considerations.

In conclusion we argue that based on macro-trends and niche developments the food chain will become much more data-driven, based on up to date ICT and will have to accept systems that make e-business and electronic data exchange the standard, moving away from a situation characterised by a low level of integration of data, although internally in companies a lot of data is already available. This will solve the mismatch between current applications of ICT and the increasing need for intelligent solutions that combine interoperability with flexibility, industry specifity and taking into account the SME-characteristics in the sector. Such a solution has a large potential impact on issues like sustainability, food safety, resource efficiency and waste reduction.

Figure 6 The Future Internet



Source: this project

Figure 6 shows some of the Future Internet functions ("enablers") that are in the pipeline and will be an extra incentive to share data in the food chain. They will also stimulate new innovations based on this data exchange, which is the topic of the next session.

[7] The FI-project FINEST has developed related ideas for a tool to find business partners in the supply chain, contract them, exchange data from in-house (legacy) systems and e-commerce activities (like invoicing, paying etc.). Smart AgriFood focusses on using interoperability for improved management, logistics and consumer data.

7 Innovations based on the regime change – playing Jules Verne

System innovations very often have quite different aspects than their original purpose. They lead to big social changes. Take for instance the example of artificial insemination in animal husbandry. This technology had an important effect on milk yields per cow (and thus efficiency) as the semen of the best bull could be used for many cows. The Dutch bull Sunny Boy had more than one million calves (and counting as his semen is still available, although the bull died). However this was never the intention of the technology. It was introduced to overcome the problem of venereal diseases with natural insemination by taking a bull from one cow and farm to another. In a similar unforeseen way the introduction of the car has had important effects on city development, as it made suburbs possible.

We discussed with stakeholders what type of breakthrough innovations they would see as needed and more or less realistic. In such discussions especially the following innovations where mentioned:

Yield information system and risk assessment

The existing yield measurement systems require some development, because the information and results are often inaccurate and unreliable, so organization of production is more difficult. For the same reason there are not reliable and accessible regional and national estimations. The yield measurement system in the future should ensure appropriate data for the organisation and distribution, should collect information on variation of yield from all points of the area, and should prepare a yield map and a database based on the collected information. There should be a large database about the information, which is available for all participants. The information collected by different technologies is about:

- the expected yield,
- the development of crops, fruits and vegetables
- the damages of crops
- etc.

This system might be used for planning of the production, for sales forecast, for scheduling harvesting, for irrigation network and for nutrient management. The collected individual data should be a part of a large national database from which accurate and reliable estimations should be prepared for larger areas (countries, regions, counties). The individual data should be collected through a coding system, summarized into amalgamated data for a major area, without the name of the farmers to ensure their anonymity, privacy and data security.

A risk assessment system should be developed based on the methodology of yield measurement system. There will be several large databases about crop protection, irrigation, cultivation and production information in the future. The individual data should be collected through a coding system, summarized into amalgamated data for a major area, without the name of the farmers to ensure their anonymity, privacy and data security. The collected individual data should be a part of a large and national database from which accurate and reliable estimations should be prepared for larger areas (countries, regions, counties). It will be a really big step in the area of risk assessment, because the necessary information is reliable and accurate.

Flexible parking system for delivery to shops

In larger cities to find a legal parking place near to the shops for loading/reloading is a basic and common problem – parking on a prohibited place often results in fines. Some of the businesses deliver relatively smaller amount of food to smaller urban shops which do not have a designated parking place for food deliveries. The proposed system should organize possible emergency parking for loading for a short period for an increased extra charge at a prohibited place when a free legal parking place is not available. The parking company and the logistics service provider sign an agreement in advance, where the extra charge rate, the maximum duration of the emergency parking described together with the identification of the authorized user and the method and channels, details of desired communication between the two partners and the police. If there is not any free place near to the target, and the vehicle stops and parks to reload on a prohibited place, the driver of the /vehicle could inform (e.g. via SMS) the parking company. The parking company – based on the previously signed agreement - could make a surcharge automatically for short term emergency parking. The employees of the parking company or the policeman, working on the streets get the information about this specific payment via mobile devices, thus the transport company can avoid to pay fines. Instead of that they pay surcharges.

Small depots for personalized supply of perishable foods

Consumers, producers and also retailers raised the idea of an improved access to food supply. Access to quality fresh foods, particularly fruits and vegetables needs more frequent shopping then the weekly shopping. Properly ripen fresh fruits and some of the vegetables have to be eaten within a few days after harvesting. The consumers could buy the selected fresh products daily and collect them on the way home, if a better logistic service is established. Benefits of the expected system:

- Combination the benefits of the traditional markets and the planned and organized food supply,
- Large choice and flexibility of time of shopping,
- Ensuring of the superior sensorial quality.

After a personalized web-based ordering, the ordered products would be delivered to a selected retail outlet point which is located closely to the route which is used by the consumer giving this order. On the way home the consumer can collect the pack of food prepared for him. Alternatively the personalized food pack can be delivered to his home. This system could help to reduce costs and time of delivery. For this, beyond the collecting-trucks or collecting-depots, the users need:

- a central database which collects, organizes and synchronizes the inputs, including data about details of the orders, consumers, target locations, fleets, optional delivery routes,
- simple access and availability to the data,
    - for consumers to personalize the orders
    - for retailers or transport companies to get the details of orders
- a direct, real-time connection between the parties,
- and a system of the future internet which helps.

Integrated freight and fleet management for vending machines and small retail outlets

Users expect an integrated management system which can help them to optimize the use of logistics resources and to improve the stock control and production planning. A software and/or internet supported stockholding and storage system - which helps the company to optimize its stock, and the stock recording and the stocktaking are automatic - is a common demand by the users, however, it is used already at some companies. Moreover this system should handle the necessary interactions (alarming, re-ordering etc.) automatically as well.

In the case of small sales units where there are not larger reserves in stock (vending machines, containers and tanks of liquids/gases in manufacturing, independent/small retail shops), it is expected that at the decrease of the stock to a set level an alarm signal should be sent to the supplier of the products or an automatic re-order should be generated and sent to the supplier. Since in the case of vending machines the problem is that the supplier has to deliver smaller amounts of different products to several locations, the automatic orders contain as much information as possible (what type of product is needed, in what amount and how many portions can be served from the remained stock). Thus the delivery route can be programmed after collecting and processing the information from the different vending machines. Improving the stock control is an expectation of the producers, retailers and logistic service providers as well, since they could benefit

o by the better forecast and prediction (production plan, delivery routes),

o by the reduction of delivery and production costs.

For this, beyond a GPS system, the system requires a direct, real-time and long-range communication and data transfer among the single units, the supplier and the single vehicles of the supplier. A single vending machine should have the ability to broadcast its information. This automatic alarming and re-ordering system may be used in smart households for improving the stock control in the larder or in the refrigerator, and for providing input for the preparation of the actual shopping list.

Smart household storage

Food storage is both a traditional domestic skill and is also important industrially. Food storage is becoming more important as we see how much waste originates in food industry and in households. The different kinds of food require different conditions of storage (temperature, humidity, etc.). Foods remain longer consumable in appropriate conditions. Fruits and vegetables are often harvested unripe or green. In this case maturation is a necessary step.

Food storage system should contain a storage device with different and separated boxes and control software. The system ensures appropriate conditions for different kinds of food; the users can select the kind of food (e.g. tomato) and the system determines the present condition of food with sensors and after that determines the storage parameters (temperature, humidity, etc.) of the separated box. The system communicates with a large database of storage standards. According to standards the system ensures the appropriate conditions or starts the post-maturation. There are different conditions and processes in all separated boxes in accordance with storage standards and settings. In the separated boxes several sensors are located which can measure the storage conditions (e.g. temperature, humidity, etc.). If the conditions reach the maximum permissible value the sensors will make an alarm signal to users. The system continuously monitors the processes and signals the condition of stored food and forecasts the date of maturing and spoilage.

Improved diet and health through personalised nutrition

Consumers should pay regular attention to their health and weight. However a large proportion of the population has a tendency of neglecting diet, health and weight management issues and not taking preventative measures unless the first signs of overweight and/or diseases are not visible. If the food consumption of the individual is properly recorded, monitored and compared to the recommended daily allowance significant improvements may be achieved. Typical examples include the monitoring of energy intake, for elderly people the amount of specific nutrients they need on their diet, for allergic patients the avoidance of specific products which contain ingredients for which they are sensitive, etc.

The system can monitor consumers' purchasing and the quantity of the reduction of stocks in the households, the needed specific nutrients, dietary advice, and provide the amount of the consumed food and compare it to the Guideline Daily Amounts (GDA). When the food is used the energy, nutrient content etc. is recorded (corrected by the number of portions and persons) and the daily consumption is calculated and compared to the targeted, recommended value. It will warn the consumer if the product is getting close to or is going beyond the indicated shelf-life date. The system can provide advice with different levels of stringency from recommendations through gentle warning till strong warning. This system is important because prevention has increasing significance.

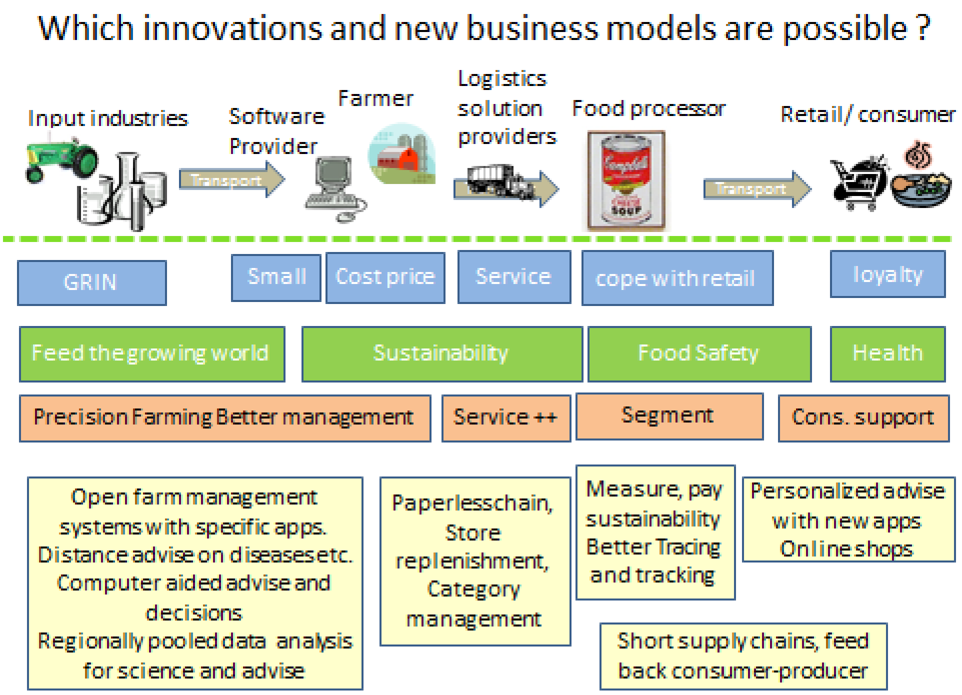
Playing Jules Verne

In addition to these suggestions that came up from stakeholder meetings, we analysed and speculated in the tradition of Jules Verne, to what the regime change to data-intensive food chains might lead. Based on figure 4, figure 8 lists some directions for new innovations.

At the farm level we assume that farm management systems become much more open and –as suggested above- work as the market for apps on a smart phone. That makes it possible for specific suppliers (sme?) to combine e.g. farm management data, geographical data and data from a soil laboratory to give specific advise on fertilizer use. Farmers can share their data with colleagues or a specialised service for advice. Such advisory services can aggregate regional data to make a better advise for risk management and spraying. These can take into account the fact that an individual farmer could be paid to spray against a disease as this is cost effective for the region (taking the externality into account that there is a risk of spreading) although this is not yet cost effective for him. With or without translating services farmers can seek advice cross-border and an extension service in a region specialised in oil seed rape could also advise such growers in other regions of Europe. In case of machine breakdown a farmer could asks quotes for immediate repair, tractor dealers or companies could inspect on line, reading out the data from the machinery and instruct a 3D printer to print a broken device on the spot while helping the farmer with online video to repair.

Farmers in an area where there is interaction with city dwellers (like hikers) could choose to make some of their data public. Not only in the form of a social responsibility report or web site, but by suggesting hikers to point their smart phone to a cow and read out its data via its ear tag and providing stories on the farm. The farmer himself could use the same technology or blended with augmented reality (see "google sky" where you point in a position of the night sky and you get the sky map in the phone screen) to video a part of his field for analysing on the fly possible diseases. For example a farmer can use his phone through an appropriate application to take a picture or video of his vegetables and these are send to a multimedia analyser to check if the plant has a disease or not.

Figure 8 Direction of innovations



Source: this project

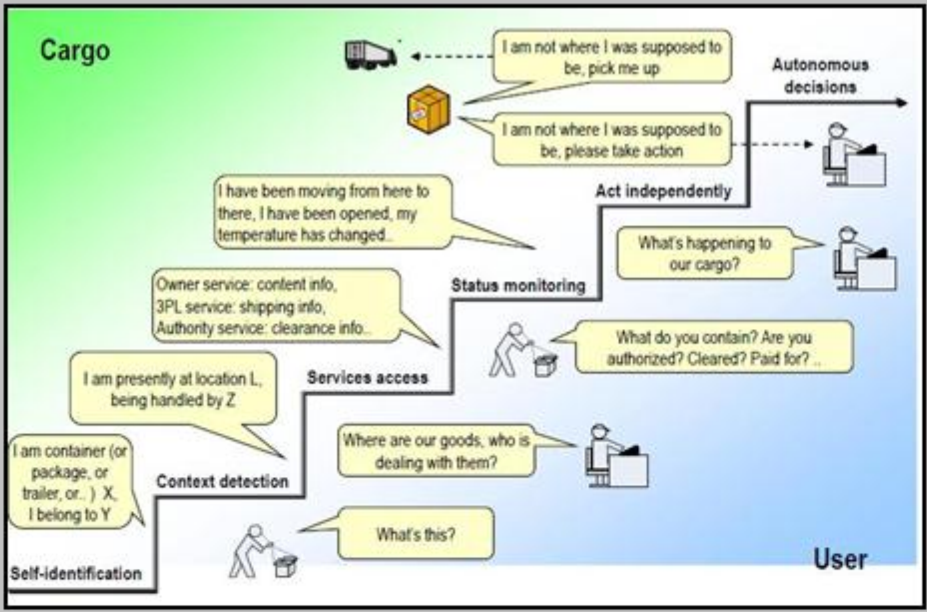
The sharing of data is not by definition free open data. It could be very well that data have a value and that a company that provides benchmark services is paying for the first 50 sets of farm data in a region and charging for the results of the analysis to the other 300 users.

More intelligence, learning and self-steering of processes in logistics

In the agri-logistics area we already discussed how more data exchange not only helps in e-commerce, but leads to higher levels of service in store replenishment and category management. It might be expected that business intelligence will be added to this and lead to much more dynamic logistics, optimal routing and rerouting of products (based on their quality decline, being perishable products) and dynamic pricing. Highly intelligent systems with learning capabilities will be installed in such processes. The next figure tells this from the point of view of the apple.

In food processing the availability of data helps in segmentation by providing more data to those retailers and consumers that are interested in it. But what starts as a service or segmentation policy could easily turn into new business models. Dairy farmers have different production methods, vary in cost prices and have different levels of sustainability, as some use more fertilizer per kg of milk than others. Imagine that a dairy company based on the data it gets from its farmers, markets the 30% milk that is produced by its farmers most sustainable under a specific brand. And that this brand sells so well that the company needs more of that milk. It will then be tempted to pay a premium and give the farmers an incentive to produce more sustainable, just as it gives financial incentives to produce more butter fat or protein per kg milk, or to produce more in winter and less in summer. It could also be that there is a political will to improve sustainability in the greening objectives of the Common Agricultural Policy by using 25% of the CAP payments to pay out to those farms that produce under such a sustainability brand as a top up on their flat rate payment – which would reinforce the commercial incentive.

Figure 8 **The Story of the Apple**



Source: Paganelli, P. (2009). The Intelligent Cargo Concept in the European Project EURIDICE. 2nd European Conference on ICT for Transport Logistics. Venice.

This is the story of a piece of fruit (apple) which was bought at a supermarket around the corner, but travelled great distances to get there. It was picked up by a consumer from a shelve at the fresh department that always contains just enough fruit and vegetables to match with demand. The store is supplied with vegetables several times a day directly by a dedicated logistics service provider ensuring the highest quality standards. This distributor real-time monitors availability, locations, quality conditions and planned harvest dates in a global network of producers and transporters. All this automatically generated data enables the distributor to create smart forecast, simulate best-before-dates and reschedule transports if necessary. This process is highly automated by technologies for intelligent cargo.

Our apple was bought during a time of year outside the apple season. In this case, the planned supply was insufficient because several harvests were partly destroyed by *Leptodontium elatius* and demand was higher than usual because of unusual high temperatures for the time of year which made apple juice increase in popularity. In the old times this would have put an enormous pressure on the distributor, but now intelligent decision support systems collected information from the future interne cloud of information services. With a single press on the button the distributor was able to restore the shortages in his stock and place new orders directly on the farms of suppliers.

Our apple only barely survived thanks to the distributors state-of-the-art tracking and tracing system. While transferring the apples from the cooled container to the cold store one crate was forgotten en left outside in the burning sun. While the temperature rose RFID tags equipped with sensors sent an alarm signal to the distributors monitoring cockpit which led to the rescue of the crate.

Finally, our apple was distributed to the supermarket relatively short after arrival. When the truck left the distribution centre the supermarket immediately received the expected time of arrival which was corrected on the way when the truck got stuck in a traffic jam. In the meantime the supermarket manager made preparations that ensured a smooth loading and unloading of goods.

Source: DoW of this project

More data sharing between the retailer and the consumer could easily lead to much more digital services. The intelligent shopping cart is a well-known example (see http://www.youtube.com/watch?v=16GiO8EEVpE&feature=player_embedded). One step further is the augmented reality, as in Google's project Glass (http://www.youtube.com/watch?v=9c6W4CCU9M4). Growers of pot plants that are connected to consumers could send them an sms or e-mail with tips on treating the plants. They could ask to send back a photo after two weeks (in exchange for a coupon for a next purchase) that could be interpreted by multimedia analysing software and provide information on the use of their plants and improve the production and delivery service. A very bold idea is to distribute food item by item through tubes instead of by vehicle (http://arstechnica.com/tech-policy/news/2010/12/want-fries-with-those-packets-introducing-foodtubes.ars).

Based on the amount of information collected about the products from farm to end-consumer, public and private administrations will be able to create alert systems. Those systems will enable the analyses of detailed information about all the products distributed, identifying retailers and consumers related with each specific item. Using these systems, and under specific regulations and public authorisation, when a food alert is required, specific alert messages can be set to the involved stakeholder be the means of a secure and fast mechanism. In this way the information will be transmitted to the people that is directly involved enabling a fast and accurate responsible.

More data with the consumer could also trigger interesting innovations. Smart phones that support the consumer in shopping with profiles on his preferred food choice could not only be based on sustainability / price / packaging preferences but also on health profiles (from butter allergy to risk of heart diseases). Inadequate nutrition is a global problem related to the quality of food, both in prosperous and third world nations. Sharing of nutritional information across the supply chain and better communication of this information to the customers can contribute to a healthier world. With help of the Future Internet people could be made aware of the fact that they are consuming for example too many calories or too few micronutrients. If this is already done while choosing products in the supermarket, awareness about these issues will raise. Such data could be shared with patient organisations for advise or with medical support or an insurance company. This of course still triggers practical questions (the shopper and the eater are often different persons) and a lot of privacy concerns and ethical questions.

Technologies based on ICT and data could also turn the food table in a more enjoyable and learning experience. At some times in some households the dinner is some junk food eaten on the sofa while looking one of those cooking programs of chefs like Jamie Oliver, when the young children are playing with farm toys and older ones with the social media game Farmville. Perhaps the creative industry could use the real farm data of the products consumed to frame a learning experience for the family at the old fashioned dinner table, where messages from the farmer are received by web cam and the farm reputations are supported by giving feedback on some of the products. A further development is to learn not only on food production, nature and food consumption, but also on many other topics (from economics to math and manufacturing), using the food chain as an example. In this way producers and consumers will be reconnected again, and not only in short chains.

Of course short chains will also develop, based on the open systems for data exchange. What starts as on-line sales and providing tracing and tracking or sustainability data, could very much benefit from ICT developments in logistics and urban mobility, concerning the so-called 'last mile' issue: it seems that on-line sales are held back due to the fact that home delivery on a moment that the consumer is at home is still hard to organize. But here the Future Internet could help in several ways, from dynamic routing trucks to opening and closing the door of a garage or box by internet on a phone call by the delivery service with authentication. It is interesting that such example came up explicitly when we discussed Future Internet innovation with stakeholders.

Open systems for data exchange, were the consumer is guaranteed a high level of transparency on the history and content of its food, leads most likely also to open data on the food system (although some of it like recipes and cost of production are for the moment and many years to come, trade secrets). Consumer as well as farmers will use such open data to organize themselves for advice, bargaining associations etc. This could be a source of innovation in itself as more people are empowered to join production activities.

In the end: the virtual supply chain

Taken all such innovations dreamed up in the project together, these innovations could potentially lead to a virtual supply chain, as is also envisioned by James Canton, a global futurist (see http://youtu.be/FovtEqDdmSQ). With the data in the cloud (or perhaps bundled with the product and accessible from the cloud) the supply chain network becomes totally virtual. The history of a product could be followed from the consumer table back to the input industry.

And one step further: as in a kind of Second Life environment one could walk through the supply chain and see what is going on at which stage at this moment, and what it's history is. This makes totally new business models possible.

8 Concluding remarks

This paper has argued that agri-food chains will be revolutionised in the coming years by ICT. Based on economic theory (evolutionary long wave theory and institutional economics) we argued that ICT will be a major driver for innovation. Based on macro ("landscape") trends and on developments in niches we showed that the current regime will be replaced by a new one. From a food chain that has an increasing amount of data but has a low level of integration a regime change will take place to a supply chain network were data are seamless shared to play an important role in (new) business models. It will solve many of the current sustainability and food safety issues and contribute to health.

This development askes for a software facility that we labelled –for the lack of a better name at the moment – an Agri-Business Collaboration and Data Exchange Facility (an ABCDEF). We then showed with a number of examples that such a system innovation will lead to a range of new innovations. Innovations that are hard to predict and that needs visionary entrepreneurs to invent and realise them. As stakeholders already recognise such developments, it's sure that there is more to come. As with all innovations there will be winners and losers. Business as usual is clearly not an option. Collaboration to learn to exploit the opportunities in the food chain is a better idea.