The Future of Agri-Food

Harnessing innovation from adjacent industries to meet global challenges

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The world population continues to grow, and by 2050 a 70% increase in food production will be required to sustain it. Science and technology is widely recognized as being a key enabler to achieving this step change. However, many businesses in the agri-food industry struggle to invest precious resources in long term science and technology. In this article, the authors explore some of the key trends and challenges in the agri-food industry, and explain how foresight can be used to both stimulate innovation and provide shortcuts to markets.

The world faces a huge challenge to feed itself over the coming decades. The Food and Agriculture Organization of the United Nations (FAO) observes that a 70% increase in food production will be needed to sustain our population by 2050[1]. Whilst food aid and international trade can provide a "sticking plaster" and population control can offer a more radical, if unpalatable, approach, it is science and technology that will need to provide the ultimate solution. Indeed, meeting food demand without damaging the environment has been identified by the United Kingdom's Royal Society of Chemistry as "the greatest technological challenge that humanity faces[2]".

But how can the agri-food industry achieve the step change in performance that it needs to? In this article we explore some of the key trends and challenges in the industry, and examine some possible approaches for stimulating the required innovation, as well as providing the necessary shortcuts to market in order to meet ballooning demand.

Megatrends and technological innovation in the agri-food industry

The agri-food business is not an easy one to be in. It is both enormous and complex. The value chain, as depicted in Table 1, contains participants who vary significantly in scale and influence, ranging from the highly consolidated and influential seed trade and retail sectors, to fragmented primary producers and food manufacturers.

Picture by Erinpackardphotography / dreamstime

[1] United Nations Food and Agriculture Organization, 2011. The State of the World's Land and Water Resources for Food and Agriculture. Summary report, Page 9

[2] The Royal Society of Chemistry, 2009. The Vital Ingredient: Chemical science and engineering for sustainable food

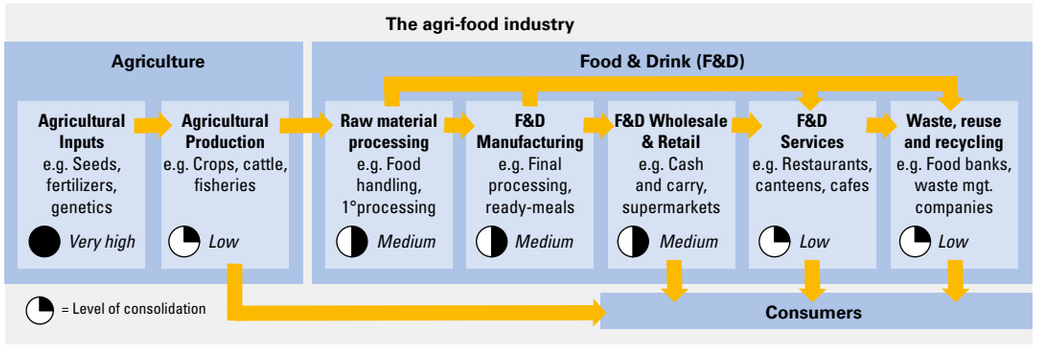

Table 1 **The structure of the agri-food industry** *Source: Arthur D. Little analysis*

The industry is influenced by a series of megatrends which are creating a long list of challenges, as shown in Table 2. In general these challenges are not easy to solve. They are both complex and highly interconnected, and there is little industry consensus on which is the most important[3].

The consequence of these megatrends is that the agri-food industry is becoming ever more globalized, with complicated supply chains reaching around the world, seeking to satisfy demand from increasingly wealthy consumers for cheap, healthy and fresh food, year-round. Companies are trying to better connect up and down their own value chains to safeguard the security of their own supply, create resilience to commodity price fluctuations, deal with environmental change, improve the traceability of raw materials and better understand their customers.

Most significantly of all, many of these challenges are associated with dealing with shrinking margins across the industry – particularly for those in the primary production and food manufacturing domains. This is because they are strongly influenced by short-term demand from powerful retailers and the consumers that influence them.

[3] For example, in the United Kingdom, Government funding regimes have deliberately avoided trying to prescribe which challenges it funds through research, and have instead allowed industry to select the challenge which it views as being of greatest importance, by allowing them to form their own consortia and bid for funding for "agri-innovation centers" under Defra's "agri-tech" strategy

Mega trends impacting the agri-food industry…	**… and creating new challenges**
Demographic shift Growing and aging population	• Overall increase in plant and animal productivity and farm output • Improved access to markets in developing countries • Education and agricultural extension activities in developing countries • Products which enable healthy aging
Health & wellness demand Consumer demand for healthy and fresh food, regulatory requirements	• Products aimed at specific consumer groups • Reduced salt, fat and sugar content in foods • Introduction of healthy food components (e.g. fiber)
Urbanization & mobility Decreasing land availability, Changing eating habits	• Plant and animal production in urban or enclosed environments • High quality convenience foods
Climate change Changing weather patterns and diseases **Shortage of resources** Regulatory restrictions **Changing energy mix** Increasing utility costs and shrinking margins	• Farming systems and practices requiring low agrochemical inputs • Energy and process efficiency improvement in the food manufacturing environment • Reducing the impact of agriculture on ecosystems • Creating resilience against extreme weather events • Improving water use efficiency in food production • Measures to improve soil health • Reducing waste and reusing waste materials
"New normal" Demand for cheap food **Globalisation** Volatile food price and uncertain margins **Economic shifts** Increasing meat consumption, Westernization of diet	• Ensuring food authenticity and avoiding food adulteration • Packaging to prolong food shelf life and reduce food spoilage • Products which prolong shelf life whilst maintaining freshness and minimizing the use of food additives • Improvements to the cold chain to prolong shelf life and reduce energy consumption • Measures to reduce the consumption of meat

Megatrend dimension
Policy and economics | Social & Health | Energy & Environmental

Table 2 **Mega trends and examples of challenges in the agri-food industry**
Sources: Arthur D. Little analysis, with inputs from: Joint Commissioning Group, 2013. Feeding the Future: Innovation Requirements for Primary Food Production in the UK to 2030. Arthur D. Little, May 2013.Mapping current innovation and emerging R&D needs in the food and drink industry required for sustainable economic growth. Report to the United Kingdom Government's Department for Environment, Food and Rural Affairs

What many of these challenges have in common is that they can be solved through innovation. However, tighter margins leave little room for investment in the science and technology often needed to underpin this. Arthur D. Little's most recent Global Innovation Excellence Survey found that food and beverage companies only invest 1-2% of their turnover in research and development, compared to 5-6% on average across other industries[4]. Our work in

[4] Arthur D. Little, 2012-13. Global Innovation Excellence Survey

setting innovation priorities in agri-food for the UK Government revealed that the biggest barrier to innovation in the industry is access to funding[5]. As a result, innovation activities are often confined to near-to-market opportunities such as making products more attractive to consumers (e.g. through nicer packaging) or finding ways to further reduce costs. With the exception of a handful of global fertilizer, agrochemical, genetics and food giants, few businesses are able to take a long range view.

So with such a daunting array of challenges, and an environment which has historically been unsupportive of the scale and extent of innovation required, what can be done?

There are two possible ways to solve these challenges: The classical way is to take basic or fundamental science done by universities and specialized institutes, and invest in progressively developing it into tailored commercialized solutions. However, this can take a long time, and is often very expensive. It is hard to envisage this type of approach alone being able to meet the world's needs, given the nature of the agri-food industry today.

A second, more promising way is to look outside the agri-food industry. This involves taking shortcuts by transferring technologies which have already matured in adjacent industries, and repurposing them to create novel solutions for agri-food. Below we look at the feasibility of this approach and examine how businesses can go about making it happen.

Exploiting new technologies from adjacent industries

Fortunately the challenges faced by the agri-food industry are especially suitable for technology transfer from outside the sector. By way of illustration, some of the ideas which have emerged from adjacent industries and entered the agri-food sector are shown in Table 3.

Interactions between animal and plant production, and consumer diet and health, have been a rich source of ideas. This is because businesses are increasingly seeking to better connect up and down their supply chains. For example, Royal DSM, a global science-based company active in health, nutrition and materials, has managed to translate its enzyme technology capabilities for animal feed products into new solutions for human health. Kagome Co Ltd., a Japanese producer and distributor of tomato-based foods and fruit juices, has developed tomato varieties which contain large amounts of lycopene, a compound which may, one day, be linked to lower cancer prevalence.

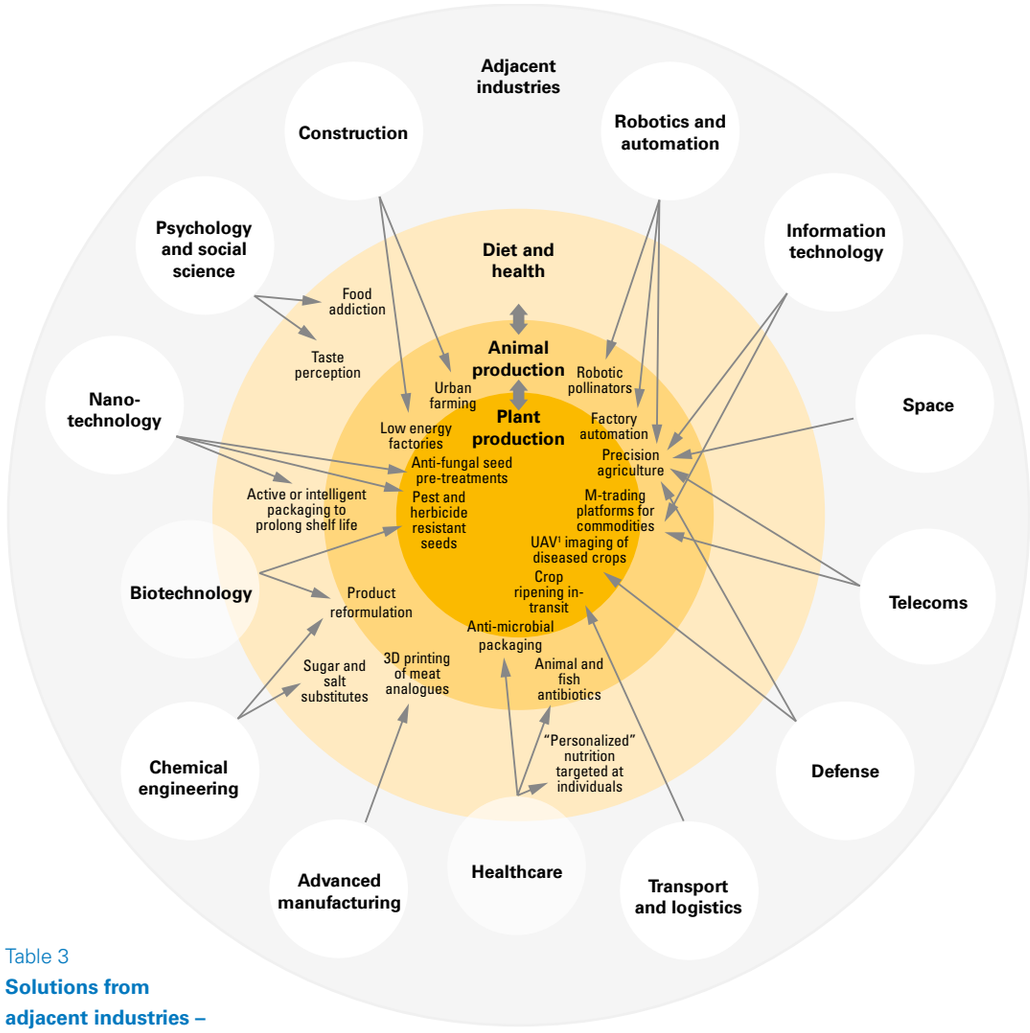

Table 3
Solutions from adjacent industries – some examples

Source: Arthur D. Little analysis and project work. 1) UAV: Unmanned Aerial Vehicle. The Healthcare and Biotechnology sectors are closely related to diet and health, and are therefore shown as slightly overlapping in this diagram. Examples are non-exhaustive

[5] Arthur D. Little, May 2013. Mapping current innovation and emerging R&D needs in the food and drink industry required for sustainable economic growth. Report to the United Kingdom Government's Department for Environment, Food and Rural Affairs

Picture by Sascha Prudkov / dreamstime

Some more radical success stories are also apparent. Unmanned aerial vehicles (often known as drones) which are generally associated with the defense industry have been redeployed for the surveillance and imaging of large apple orchards to look for diseased leaves on individual trees, dramatically improving productivity. The telecommunications industry has enabled the creation of mobile phone-based commodity trading platforms to connect isolated farmers in the African sub-continent to their markets. The Agra-Alliance Market Access Program, for example, reports that approaches such as warehouse receipt systems, commodity exchanges, and market information systems contribute to a 10-35% improvement in incomes for smallholder farmers by reducing post-harvest losses and transaction costs[6].

Another excellent example is precision agriculture, described in Box 1, which illustrates how the space, satellite, defense and electronics industries have converged to help arable farmers use less agrochemicals whilst maintaining or increasing crop yields – and therefore improved their profits.

[6] Agra-Alliance Market Access Program. Available at: http://agra-alliance.org/what-we-do/market-access-program/#.VBChmSgoAW8; accessed September 2014

Box 1 Precision agriculture: The influence of the space industry on food production

Precision agriculture involves observing, measuring and responding to inter and intra-field variability in fields of crops. It draws on technologies such as satellite imagery and remote sensors to track changes in environmental conditions such as soil moisture or nutrient levels. This allows farmers to decide exactly where agrochemicals need to be applied – almost to the level of an individual plant. This helps avoid wasting expensive agrochemicals on plants which do not need them, and also reduces the volume of these agrochemicals entering the environment by, for example, being washed off fields and into adjacent rivers during periods of heavy rain. This intelligence, together with the use of Global Positioning Systems (GPS) on farm machinery, can create semi-autonomous approaches for farming. For example, Blue River Technology Inc. uses image processing to establish the shape and density of lettuces to create automated lettuce thinning systems[7].

[7] CEMA (European Agriculture Machinery) - Precision farming: producing more with less. Available at: http://www.cema-agri.org/page/precision-farming-key-technologies-concepts, accessed September 2014. Blue River Technology - Current Solutions, Precision Lettuce Thinning. Available at: http://www.bluerivert.com/; accessed September 2014

All of the solutions described above involve applying technologies that already exist, or are starting to mature, in a new way to deal with complex challenges in the agri-food sector. In the example of precision agriculture, GPS technologies are now becoming commoditized, and in-soil sensor technology is starting to become so cheap that sensors can be ploughed into the soil, where they biodegrade naturally once their purpose is fulfilled. The design of energy efficient houses is now commonplace in many developed countries – but comparable approaches are practically non-existent when it comes to building food manufacturing factories which sometimes require vast spaces to be cooled whilst processing chilled foods.

Foresighting as a key lever for success

Solving the difficult challenges described above can involve using a maturing technology from an adjacent industry to create a novel approach. However, businesses in the agri-food industry seldom have a sufficient long-range view over what challenges will be solvable by technology in the future, and – in particular – where developments in adjacent industries could provide answers.

For this reason we see foresighting as a key lever for the agri-food industry to unlock the potential of innovation from adjacent sectors. As well as understanding challenges and potential solutions, foresight of adjacent industries also helps to inform sound investment decisions into unfamiliar territory. All too often, businesses and investors are wooed with stories of technological advancement, only to find that a technology is not ready for large-scale deployment. For example, many businesses in the dietary supplements sector set out to use marine microalgae to produce very high value nutritional products, but found that the associated manufacturing technology is not yet mature enough to do this at scale. Likewise, those in an adjacent industry may be sitting on a mature or declining technology, and struggling to think of ways to capture value from it today.

Based on experience in the industry so far, we suggest a number of practical steps which both those in the agri-food industry and those in adjacent industries can use to inform their innovation management processes to meet the challenges of the future – and gain competitive advantage:

Those in the agri-food sector need to establish what their future needs might be, and then use them to stimulate the development of new ideas. They can achieve this in three steps:

1. **Agreeing on what challenges to address in the future.** This involves examining megatrends and then establishing, on the basis of these, which challenges are relevant to their business and need to be resolved by going forwards, and which can be solved by technology. "The Trends in Megatrends", an article in this edition of Prism, describes an approach for achieving this.
2. **Conducting a "horizon scan" for technologies in adjacent industries.** This involves taking relevant challenges and seeking the opinion of an expert group of scientists drawn from adjacent industries to propose relevant technologies to address them over a medium to long range time horizon (e.g. 10-15 years). Successful horizon scanning requires considerable preparation, and may involve several workshops to agree on market drivers and competitive trends before relevant technologies can be identified. Key questions to ask during this horizon scan include:

   – When is the technology likely to mature?
   – Will there be an attractive market for it in the future?
   – To what extent is the technology tangible and proven in adjacent settings?
   – How much cost and effort would be required to adapt the technology?
   – What activities have competitors already undertaken? Where have others failed, and what can be done differently this time?

3. **Communicating technology needs to innovators.** There is an opportunity to influence those in adjacent industries which could provide a solution, as well as stimulating ideas amongst the innovators, or "intrapreneurs" within agri-food businesses themselves. Broadcasting the results of foresighting work is not commonplace in the agri-food sector – though some, such as PepsiCo, conduct foresighting activities and publish their future needs within their annual report as part of a stance to "future proof" the business[8]. Other industries do this very systematically: Royal Dutch Shell Plc publishes its Future Scenarios on a regular basis; IBM Corporation produces an annual Global Technology Outlook, which is shared both internally and with key collaborators.

Some organizations have realized considerable success by anticipating future developments and responding accordingly. Trimble Precision, described in Box 2, has been progressively acquiring businesses from adjacent sectors to build up a new business line in precision agriculture.

[8] PepsiCo annual report, 2013. Introductory letter from Indra K. Nooyi, PepsiCo Chairman and Chief Executive Officer, March 2014, pp.5-8

Box 2 Trimble Precision: From marine navigation to precision agriculture

Trimble Precision started out in 1978 as a provider of positioning and navigation GPS related products for the marine navigation market. Between 2000 and 2013, Trimble acquired a number of agricultural machinery companies associated with automated crop spraying and planting. This approach has positioned Trimble as one of the main business-to-business providers of precision agriculture systems to the agri-food sector[9].

[9] Trimble Precision – Company History. Available at: http://www.trimble.com/Corporate/About_History.aspx; accessed October 2014

Adjacent industries also require foresight – but over which of their existing technology capabilities are due to mature, and where they can apply original ideas to the agri-food sector. Envisioning the future and developing new business models and solutions can revive even the most mature technologies, and make them powerful components of new business models.

Insights for the executive

The agri-food sector needs to realize a technological step change to increase productivity and meet consumer demand without further damaging the environment. It has limited resources for innovation, and needs to think creatively to achieve this. One approach is to take maturing technologies from adjacent industries and then re-deploy them as new products and services in the agri-food sector.

For those in the agri-food sector, achieving foresight over what challenges need to be addressed in the future is essential. These should be communicated as broadly as possible to those in adjacent industries, as well as to those within agri-food businesses themselves, to help recognize unique qualities in existing technology.

Those in adjacent industries need foresight over what existing components of the product or service portfolio are due to mature in the near future. This then helps to prioritize which capabilities need to be most aggressively marketed to new sectors as "step out" opportunities.

Applying the principles described above can help avoid "reinventing the wheel" whilst creating the step changes that will be needed to feed another 2 billion people by 2050, in an industry where funding and resources for science and technology are limited. Key to this is foresight, both over what challenges need to be solved, and what solutions are likely to emerge from adjacent industries to meet them.

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