A Nuffield Farming Scholarships Trust Report

Award sponsored by

Royal Norfolk Agricultural Association

Knowledge Transfer in UK arable farming:

bridging the gap between research and application

Mark Bowyer

October 2015

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: October 2015

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	Knowledge Transfer in UK arable farming: bridging the gap between research and application
Scholar	Mark Bowyer
Sponsor	Royal Norfolk Agricultural Association (RNAA)
Objectives of Study Tour	To examine how new technology is relayed to farmers and end users and how and why many fail to adopt it.
Countries Visited	Australia New Zealand Brazil Argentina USA

Messages

1. A chasm is considered to lie between research and adoption. This needs to be bridged in 2 directions in order to effectively convey information between researcher and end user.

2. A large number of individual organisations are involved in their own forms of R+D and extension; however there appears to be little co-operation or co-ordination between them.

3. The current system of unsustainable support payments is enabling the industry to maintain traditional practices and may be counteractive in enabling or encouraging businesses to develop and become sustainable. It may also be supporting land values at unrealistic values.

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, or of any other sponsoring body.

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Published by The Nuffield Farming Scholarships Trust
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1. Personal introduction

Having worked as a farm manager on five different units in the last 20 years I like to feel that I am a farm manager and agribusiness developer.

I am not from a farming background; neither of my parents has been involved in agriculture or the food industry but all I have ever wanted to do is to farm. With no family farm to rely on I decided that farm management may be my only way into the industry, so I studied agriculture to Honours Degree level at Harper Adams, graduating in 1991. My first position was as an assistant to a farm manager on a developing business on the Shropshire/mid Wales borders. In my 4 years there I saw the farm expand from 1700 acres to 2400 acres, and the potato business develop to 750 acres from 300. This drove my passion for development, expansion, growth and change.

Figure 1: The author Mark Bowyer during the American leg of his study tour

Since then I have always been looking at how businesses could improve their activities. I studied for both BASIS and FACTS certificates so that I understood the advice that specialists were giving and this enables me to ask the all-important question*: 'Why?'* More importantly I hoped it would give me a chance of understanding the answer, and whether a further '*why*' was necessary.

I now firmly believe that the emphasis on UK agriculture has changed; we can no longer operate a business solely by being good farmers, we also need to be good business people. In such a model the best expertise in every area can be used to form a strategy and policy from which the whole business can benefit.

My study project is driven by my passion for improvement and understanding technology and change. In presentations to some agricultural students I was alarmed about the level of pre-conceptions and lack of basic understanding some of the students held, and how little motivation they had for change, especially as they are the future for UK agriculture.

Since I started this project the rate of change in agriculture in the UK has accelerated drastically, and I now believe we are in the third agricultural revolution.

2. Background to the report

The world is an ever changing place, and man's influence on it may not be purely beneficial. World population is still growing whilst our finite resources of land, water and sunlight remain relatively constant.

Many have commented on how we are to economically feed 9 billion mouths by 2050 without destroying the planet we live on. The answer is likely to be: through sound, well tested science. But in order to employ this science we need to ensure that it is the *correct* science for the region. Our farmers, growers and the food chain need to understand it: how to apply it, its weaknesses and strengths, threats and opportunities. This is the role of Knowledge Transfer. In return our scientists need to understand where the problems lie, and need the farmer's help in finding the solutions.

Agriculture is a very traditional industry worldwide, and nowhere more so than in the UK. Change does not come easily, and long production cycles mean that the measurement of success or failure does not come quickly. No farmer wants to be the generation that fails and loses the family farm, and this has led to farms being even more risk adverse.

I started this project with three questions:

- When there is a third agricultural revolution, is the UK in a position to take part?
- Is the UK still a leader in agricultural development? If not, why; and why are the 'best' the best?
- Is the system of agricultural subsidies in the EU stifling change or encouraging it?

I also had a number of preconceptions:

- Basis payment and area support underpin UK businesses and support uncompetitive operators.
- The level of support has made a break-even position an easy and comfortable place for many farm businesses.
- Farms had become so risk adverse that they would not enter into any form of development without government handouts.
- Research in the UK was now suffering because of the lack of innovation and drive coming from UK farms.
- Taxation and reliefs to agriculture are making it more difficult for new and younger people to enter the industry.

Has anyone shot me yet?

I would like to think that this report has changed some of my preconceptions and widened my view on the place of UK agriculture in a worldwide farming system. Please feel free to contact me with any questions that arise from it.

3. Study tour

My tour has taken me to Australia and New Zealand (February 2013) to see and understand how farmers are adapting to a challenging climate and looking at both attitudes and opportunities. I have reported little from the southern hemisphere in this report, as I felt that there are more key findings in North and South America.

In February 2014 I visited South America (Brazil and Argentina) with a Nuffield Farming colleague, Russell McKenzie. I wanted to see how farm businesses were developing without subsidies and with more limited control and legislation. I was also interested in the ability of businesses to change when there is little history and few preconceptions. I wanted to understand the importance of Embrapa (Brazil's Agricultural Research Corporation) in a developing nation.

Finally in June 2015 I visited North America, spending time in the USDA (Washington DC), the University of Maryland, and with ARS in California and the University of California, Davis. The idea was to examine how the government support for R and D and co-ordination of research and translation worked in practice, and what learning there may be for the UK.

Finally I looked at the UK, which has European support payments and a multitude of research and development programmes funded in a wide variety of different ways.

My report details some of the major findings from some of my travels. This is not exhaustive, but is aimed at outlining some of the more successful techniques used to help the development of farm businesses. I begin in the next chapter with an account of what I found in the USA.

Country visited	Date of visits	Reason for choice
Australia	February 2013	To see how farmers are adapting to a challenging climate
New Zealand	February 2013	
Brazil	February 2014	To examine government support for R + D and look at adoption, with particular reference to Zero Till
USA	June 2015	
UK	Ongoing	Looking at the support payments and the many R & D programmes with their diverse funding

4. The USA

4.1.i. Overview of Research and Development in USA

> *'a well developed industry with limited direct financial support from national or local government'*. Mark Bowyer

The USA is considered to be one of the most developed nations of the world.

There are approximately 160 million hectares (*USDA, 2012)* of arable land in the USA, but this is falling year on year as land is developed or abandoned as 'no longer suitable for production'.

Agricultural commodity prices are not keeping pace with rising prices in the other areas of the economy and this is decimating the smaller businesses. Total agricultural sales in 2007 were a staggering $297 billion. Of this approximately 3% was contribution from government in various forms of subsidies.

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Approximately 30% of agricultural production is exported.

In 2010 agriculture contributed 5% to GDP yet employs only 2% of the workforce. (*US environmental protection agency 2014*). The average age of a 'farmer' from the agency's last survey was 58 years old, one of the oldest average ages I have come across.

Food safety and security are very high on the government's agenda, along with sustainability. These requirements are monitored by the US Department of Agriculture (USDA) which is also responsible for supporting the industry by ensuring food security/safety, environmental protection, the protection and development of rural economies, and a desire to help to feed the whole world with healthy food from sustainable sources.

The current trend in food marketing in the country is for a shift towards locally produced produce as well as a continuing expansion in organic production. This is evident in both major and minor retailers and has opened real opportunities to farmers growing crops and livestock close to urban areas. There is also an increased interest in farm practices and how food is produced. This new interest is being seen by both producers and retailers as a great marketing opportunity.

In the early 1860s the USA founded a series of land grant colleges. These were set up under the Morrill Acts which granted federally controlled land to the individual States for them to sell or use to raise the funds to establish education institutions to focus on the teaching of practical agriculture, science, military science and engineering.

By 1887 a further act was passed which provided extra funds for these colleges to set up a series of agricultural research stations. This was known as the Hatch Act, and was then strengthened in 1914

by the Smith-Lever Act to incorporate the extension work as well as base research. This resulted in the employment of a large number of extension officers.

These colleges still have an obligation to carry out research and provide extension services to environmental development. The scale of this commitment relates to financial output from the individual state. In some states this can result in 450 extension officers being employed.

Having spent time with some of these extension officers on both the east and west coasts of the USA it is apparent that there are vast variations in the successfulness of this program. One example in Californian saw the almond growers chasing their extension officers for trials results and trying to 'second guess' results and adopt practices that were still not proven, whereas in the same region other projects to improve the use of water were brushed off and ignored, even when facing a water crisis.

4.1.ii. Public sector research

As well as this research and development (R+D) in academia there is also a nationally operated R+D program run by the Agricultural Research Service (ARS)

ARS is part of the state-operated US Department of Agriculture (USDA). It employs approximately 2000 'career scientists' and another 6000 operatives on 90 locations in the USA and several overseas locations.

There are 17 national programs, and these lead to 750+ ongoing research projects. Most of these are 'near market' projects answering specific problems, but they are also responsible for the operation of the national agricultural library, the national arboretum and maintenance of the national germoplasm bank.

Total funding is c. $1.1 billion per fiscal year, and this is currently being maintained. Additional private funding can be added to accelerate certain projects. ARS can apply for some of the grant funding available from other areas of the USDA if it is relevant and appropriate.

Knowledge transfer and extension are also key parts of the brief of the ARS. This is not only to disseminate knowledge back to growers, but also to lead the direction of future research.

As well as working in the US the ARS has several overseas operations working on projects that may become relevant to the USA in the future. In many cases these act in partnership as with Embrapa in South America, but also operate in India and China.

4.1.iii. Project selection. – The Office of National Programs

This consists of approximately 30 Program leaders drawn from different scientific disciplines and work across all of the country.

Projects undertaken by the ARS aim to:

- Ensure the production of high-quality, safe, food and agricultural products

- Help development of the nutritional requirements of Americans
- Build a sustainable agricultural industry
- Protect and enhance the environment for the benefit of everyone
- Ensure that rural communities survive through trade and development

In order to achieve this, the country is split into 5 regions:

Pacific West : Plains : Midwest : Northeast : and Southeast

Each region has its similarities and differences, but in general the openness of the State-funded system ensures that there is little duplication of work.

Each of these regions has its own requirements, and projects are determined through a variety of processes. Most projects are planned on a 5-year cycle which can be renewed or extended for the longer term if required.

1. State intervention – at the highest level, senators or the State as a whole can legislate that certain areas of research are carried out for the 'national good'.
2. Consumer and peer panels (Stakeholder Workshop). The aim is to bring representatives of all areas of the supply chain together to try and identify the specific problems to which a solution is needed. This also tries to prioritise the work that may need to be done. This ensures, too, that the research is driven toward problem solving rather than 'interest' or exploratory work.

The process

Having identified the required projects the project area leaders outline the requirement to the individual scientific research team, who then write a proposal as to how the objectives are best met. The team also put together what the project will cost, with its justifications. The project tends to stay in the region where it is proposed - for obvious reasons. There may be some duplication of projects across different regions due to local requirements and variations. At this point there is enough funding for all the proposed projects, so the rest of the process is not competitive, but research teams cannot start on a project **until** it has been approved. Should a project not be approved even after it has been revised the research group will effectively be disbanded or apportioned to a new project.

Having written the proposal and the 'milestones' (which are virtually Key Performance Indicators) this is assessed by the 'Office of Scientific Quality Review' or OSQR as it is known.

The role of OSQR is to ensure that the projects proposed are credible, possible, useful and are within the original brief. This is carried out through a peer panel. This panel consists of leading academics, and industry leaders. The identity of these panel members remains anonymous, allowing them to have complete impartiality and provide constructive criticism plus evaluate the projects chance of success.

It aims to evaluate the project on:

- Its relevance to the problem
- Its chance of success

From this the proposal is rated by the panel and returned to OSQR for final approval.

A few projects which score poorly on the chance of success are still perused as they may provide essential information or may be required by the Senate. This is authorised in the same way as high scoring projects.

This process is similar for the projects in the off-shore and international centres, where research into specific problems seen outside the US can still be carried out as they could be a potential issue in the future, or are seen as a threat to international or worldwide food security.

This is not a competitive process; there is agreed funding for all the projects at the start. Any 'failures' result in the funds being returned to the Treasury; it does not make extra money available for the remaining projects. Funding is also on the 'use it or lose it' basis.

4.1.iv. Measurement of success

In the preparation of the proposal researchers are required to put in annual milestones, against which they can be assessed. This is the key route to success as it tends to deliver results that end up being translated into a change of production. The funding is also assessed annually to ensure there are no large surpluses to be returned at the end of a project. Final success of a project is not quantified by the number of scientific papers or citations, but by the production of a product or technique that can enter into the marketplace. This appears to be fundamentally different to many other research organisations.

4.1.v. Extension

In general, extension partners are selected by the research team. The work done by ARS is available for public access and, in selecting an extension partner, individual agreements are prepared. Generally there are few or little intellectual rights to the work. The original researcher is only likely to be recognised if they publish their work in the form of a paper. Their personal achievement is recognised by the translation and application of the work. This then allows the team to work on a fresh project or continue to work on the next stages of the problem.

Extension partners

Generally small businesses that specialise in the field are invited to become involved. In situations where little or limited further work is required the 'partner' is expected to bring the process, technique, etc, to market without necessarily the protection of patents or IP agreements. This passes the emphasis to the partner to ensure that the translation is done well, and properly marketed. There are other sources of grant available from USDA to help in this situation.

In more complex situations where registration of a product or testing and licensing is required there are opportunities for the partner to have agreements in place to ensure that they protect their further investment. This is aimed at ensuring that new products are licensed and come to market without further input from ARS.

Worldwide program

The aims of the worldwide program are similar to the system within the USA but allow the opportunity to work on problems that have not yet been seen in the US. The program was heavily involved in the development of 'golden rice' and is also looking at diseases and parasites that may challenge agriculture in the US in future years, as well as benefiting the countries where the problem was originally identified.

4.2. Academic research

Under the Hatch Act land grant universities were required to set up agricultural research stations. The Smith-Lever act followed, requiring them also to provide and operate an extension service which covers all forms of rural affairs, from remote energy production to food research.

The scale of expectation and existing funding is calculated by the federal government from a formula which looks at the size of the State, number of people, their area of employment and dependence upon the rural economy.

This should put the universities in a similar research situation as ARS. There is match funding available to fund projects, but generally academia is looking at longer term privately funded projects that could be covered by intellectual property agreements.

4.2.i. Identification of projects.

The aims of university research are similar to those of ARS. The availability of information from extension officers should start to highlight concerns. Peer reviews also occur, plus there is an input from the State. The State can use legislation to ensure a project it feels necessary is researched.

As well as the grant monies there are also several competitive funding steams available to universities. They may also be involved with projects with ARS.

In general, projects in academia are 4-year projects. They are re-assessed every 3 years, with option to extend to a fifth year if required.

4.2.ii. Project evaluation

A similar project evaluation occurs in academia, known as 'murder boarding'. In this case an assessment panel of industry specialists (from all parts of the supply chain), plus academics will try and consider all the merits and weaknesses of the proposed project.

For example, some projects have been shelved because the industrial processes involved in the commercialisation of the activity may be too dangerous or too costly. A good example of this is the development of polythene polymers from plant sources rather than from oil. Although the process works and can be industrialised it only becomes economic when oil exceeds $100 per barrel. This project is now on hold.

These organisations feel that they are helping lead 'Innovation and change' in the USA.

They also aim to have a 'current research information system' with the aim of sharing knowledge both locally and nationally and with ARS. This is aimed at reducing the risk of parallel work occurring, although every State will also consider their problem different to everyone else's and the principle of a shared knowledge pool may not always be observed by all!

4.2.iii. Monitoring of success.

In general the research in academia is considered to be further from market than that of ARS. The shorter term funding cycle has also led to the involvement of industry earlier in the development process.

This research will, in general, tend to lead to more academic papers than the work of its competitor, ARS. The reason for this can be attributed to a large number of researchers who are starting their careers, or individuals whose role is not solely research. In academic fields there appears to be a culture that academic papers printed in publications such as 'Nature' is a measure of success. This appears to be common to academia throughout the world.

4.2.iv. Extension.

This forms part of the institution's obligation to the federal government. It also covers all areas of agriculture, forestry, rural life and the rural economy. This makes the brief incredibly wide. The University of Maryland, for example, employs approximately 500 extension personnel.

In general these officers are well respected as providing the link between 'pure science' and its application.

Due to the funding constraints many projects become partnered with industry in their early stages, and in these cases most of the findings and applications are covered with IP agreements long before they are 'market ready'.

Other forms of extension carried out by the universities include public field days; these try to reach out to the industry and the general public. This introduction to the general public is used as an 'acceptance test' – i.e. will the public accept this development?

4.2.v. Education

It must be noted at this point that academia's first objective is education. In discussion with the Dean and his Directors at a land grant university it was interesting to hear that student applications to study agriculture were falling, and that there were a significant number of applicants who were not from a farming background. This to them caused a problem, as some students lacked the background knowledge but had no preconceptions, whilst the students with background knowledge also had the preconceptions. There was also some concern that numbers were falling and agriculture was not always seen as a 'career'. This is not unlike the situation seen in the UK in the early 2000s. This is causing another major problem: the universities are obliged to provide courses in agriculture and operate demonstration and research establishments but cannot fill the courses. In

order to address this situation the colleges are undertaking more open days to try and educate the public on food and farming.

4.3. Research grants for private projects and privately funded research: The role of USDA

The program is overseen by NIFA, the National Institute of Food and Agriculture.

Its primary role is to encourage small business research and development through training and education. Modest grant packages are available to further this process, but it is not 'free money' to start a new business as many people believe. Extensive publications are produced working with knowledge gained from some of its grant assisted projects as well as from commercial research.

A key part of its role is to link 'ideas' and 'inventions' with end users for their mutual benefit.

There are three main programs, but much overlap between them.

4.4.i. SBIR – Small Business Innovation Research program

Grants can be applied for by private business or individuals. Open to all areas of agricultural and rural development that fall into the following areas:

1. **Air, soil and water** – creates technology for conserving and protecting essential resources whilst sustaining farm and forestry productivity.
2. **Animal production and protection** – develops and markets technologies to help producers improve productivity and prevent disease outbreaks, conserve resources and reduce the cost of production.
3. **Aquaculture** – improve private sector production and competitiveness whilst maintaining water quality and reducing water usage.
4. **Biofuels and bio-based products** – promotes usage through innovative technologies and introduction into the raw materials industries.
5. **Forest and related resources** – health, productivity of forests and grasslands through sustaining forest resources and addressing climate change impacts, developing value-added materials and protection of existing ecosystems.
6. **Plant production and protection – biology** – enhance production through biological advances, reduction of the impact of harmful agents and developing new food and specialty crop plants.
7. **Plant Production and Protection – engineering** – development of mechanical systems to maintain plant health and crop safety both pre and post harvest and during storage.
8. **Rural community development – conceptualises and commercialises new and existing technology, products, processes and services** that enhance both public and private investments to help build and maintain a diverse workforce, increasing resilience to natural and human disasters and improving the economic vitality of rural communities and the reduction in poverty.
9. **Small and mid-sized farms** – increased sustainability of farms and ranches through new developments and improvements in farm safety, operational efficiency and conservation of natural resources.

The idea is to help small businesses develop. Total grant is $600k per application, and this is split into 3 parts:

1. **Feasibility study**. $100k is made available to develop the proposal and plan. It is expected that this be submitted within 6 months of the initial payment.
2. **Development of prototype**. $500k is made available for this stage, and completion within 2.5 years is anticipated.
3. **Commercialisation.** No financial award is made; it is anticipated that by this stage third party intervention takes over to bring the prototype to market.

Extension. With this grant scheme there is little extension to the general public or to industry, but it does support the setup of small innovative businesses. Due to this there are cases where very similar projects are completed with grant money.

This Small Business Innovation Research program has been highly successful, with notable achievements in the development of robotics to incubate poultry chicks before hatching, and the manufacture of the airborne turbine for electricity generation in remote 'off grid' areas.

4.4.ii. Sustainable agriculture research and education. (SARE)

This is probably the area where NIFA has the highest impact.

It offers grants to all forms of agricultural specialists plus the wider industry to support projects into:

- Pest management
- Energy
- Stewardship
- Marketing
- Systems research
- Organic practices
- and many other areas.

To do this it focuses on the 3P's of sustainability:

- Profitability – over the long term
- Protection – of the nation's land and water
- People – who depend on agriculture

The program splits the country into 4 regions each with a 'council' made up of producers, educators, scientists, government, producer organisations and stakeholders to set priorities and make grants.

The program is also responsible for the publication and availability of a wide range of practical information for the whole of the industry.

Due to the nature of this work nearly all the projects involve extension rather than grant-aided research. This, along with its work in education of parts of the whole supply chain, is probably part of its success.

4.4.iii. Beginning farmers and ranchers program

This program is designed to address the issue of the ageing farmer population. Although it cannot supply land and find new farms it does assist in the setup of new farms and rural businesses.

This occurs through training and mentoring programs throughout the whole process, but with particular emphasis on marketing and mentoring. The program will also help new entrants secure funding for ventures and, where applicable, make the introductions to allow new entrants to meet existing producers.

The whole project relates to training and education of leaders and teachers in order to disseminate knowledge into the community.

4.5. The role of the producer organisations

These organisations are generally funded by state and producer levy. Their membership is high, and they help form the vital link between the producer and research. Often these organisations are responsible for the publishing of both research and marketing results.

Representatives from these organisations are heavily involved in both the academic and public research as well as commissioning private work.

5. Brazil – a less developed agricultural country

Formal agriculture in Brazil has only really taken off in the last 50 years. Development started in the southern states in the early 1900s with farmers growing soy, corn, rice and beans. The early pioneers came from both North America and Europe, with a large contingent of German farmers. The development in the southern regions also saw the start of the no-till movement (a pioneering process which spread quickly). Many of these farmers expanded into the northern states, taking their practices and principles with them, just increasing the scale.

I thought that being a much younger agricultural community there would be fewer preconceptions and traditions. In general this was the case, but there was still an attitude in a few of the older individuals that there could not possibly be anything they could do better, and they had a complete ignorance of the risks of compaction, deteriorating soils and climate change. The average age of the farmer is estimated to be 52.

It also became apparent in conversations that generally the most forward thinking businesses were the most professionally run, often with an 'innovator' who tries new ideas and looks for different solutions whilst a manager puts the actions into practice. This appears to ensure that attention to detail is a farm responsibility whilst new ideas are tried and tested.

(Brazil's) main problems now appear to revolve around moisture retention, soil erosion and a breakdown in the GM crops.

A shortage of infrastructure does create challenges; however a good communication system exists and is adopted by most.

The short growing season and multiple crops per year resulted in the effects of change being seen in 2 or 3 years. The main problems now appear to revolve around moisture retention, soil erosion and a breakdown in the GM crops. This latter is a major concern for the breeders, who feel that the intensive multiple cropping will result in a build-up of resistance faster than they can develop its replacements.

5.1. Agricultural research: public funded

As agriculture developed the need for agricultural research and translation was identified. This led to the formation of a public funded body called '*Empresa Brasileria de Pesquisa Agropecuarias*' or EMBRAPA. This body is still in the top 4 of internationally funded agricultural research bodies with a national budget of c. USD 1 bn

Embrapa was set up to oversee and enable the technological development of agriculture in Brazil. Having seen the potential for production in Brazil, it was instrumental in the adaptation of soybeans to grow in hot and humid climate on the acidic and recently reclaimed soils.

Embrapa consists of 46 operational centres, with 17 more central 'management' units. Overseeing all of this is a central headquarters which operates all of the administrative roles such as finance and human resources. This centralised management structure is a very up to date model, now being adopted by many large organisations in the UK. Despite this, of the 9,800 people employed only 2,500 are actual researchers, and of these more than 80% hold PhDs. The rest of the staff is considered to be technicians, assistants and perform the admin role, as well as a significant number of extension officers who perform a key operation.

According to Figueiredo (*Figueiredo, PN, 2014*) its effectiveness may have been due to:

1. The orientation of its research towards specific local needs and demands.
2. The innovative process led by Embrapa. This is based on systemic interactions with diverse components of the indigenous institutional infrastructure, and industry partners rather than a linear process of its own research.
3. In the case of the soybean industry, Embrapa works with networked partnerships, especially with subsidiaries of multinational enterprises. This adds to the developments by the multinationals and also forms joint extension programs. This program may well also become international.
4. Innovative activities that have had a significant impact on productivity growth do not necessarily reflect only research and development efforts, but also the effective creative imitation efforts of individuals, groups and multinationals.
5. Some 'hard core' long term projects are still carried out, but the processes and checking activities try to minimise the duplication of work.
6. Maintenance of a national gene pool.

As well as carrying out its own research and extension, Embrapa also co-ordinates the National System of Agricultural Research (SNPA – *Sistema Nacional de Pesquisa Agropecuária*), in a similar way to the Office of Scientific Quality Review in the USA. Created in 1991 this system involves Embrapa and its units, nearly 20 State research organisations (OEPAs), state and federal universities and research institutes, as well as other public and private organisations related directly and indirectly to agricultural research. The idea was that, through the technical and financial support from Embrapa, these local institutions would work in closer contact with local needs (see illustration in Figure 2 on next page). (*Figueiredo, PN, 2014*)

The mission of Embrapa remains: "to *develop research, development and innovation solutions for the sustainability of agriculture, for the benefit of Brazilian society".*

As well as co-ordinating research in Brazil, Embrapa is heavily involved with international work, with strong links into the USA and Africa

In 2008, public agricultural R&D spending in China, India and Brazil (the three top-ranked countries in terms of public R&D spending) accounted for 25% of global public agricultural R&D spending

In 2008, public agricultural research and development (R&D) spending in China, India and Brazil (the three top-ranked countries in terms of public R&D spending) accounted for 25% of global public agricultural R&D spending and 50% of combined spending in the developing world.

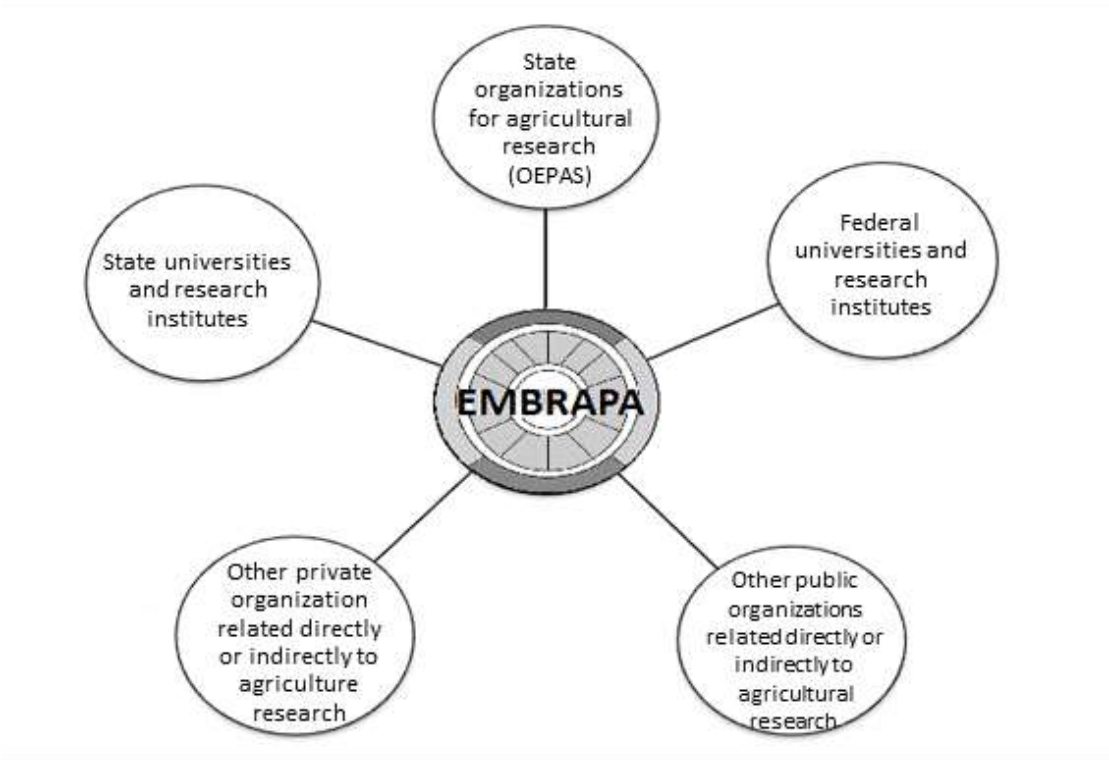

Figure 2: Embrapa's responsibilities *(After Figueiredo, PN 2014)*

5.2. Private and corporate research

Embrapa suffered a period of perceived underfunding in the mid 1990s and early 2000s which appeared to limit some of their research. This led to certain areas of research – in particular the area of biotec crops - being sidelined and 'picked up' by other multinational organisations. Most of the longer term 'hard core' and further-from-market work did continue, in particular a lot of work on the use of potash in continuous cropping systems where some trials have now been running for in excess of 25 years. This investment by the multinationals into the 'near market' areas of genetically modified plants has led to acceptance within the organisation that industry leads the work in genetically modified plants. This has allowed the rapid development of biotec crops.

Embrapa are still involved in much of the final verification work, and the industry generally feels that true testing and assessment of varietal performance should be undertaken by the public body (often funded by industry) to produce impartial results.

5.3. Knowledge transfer – extension (State)

In its operation as a researcher Embrapa is also responsible for its own knowledge transfer program.

Embrapa considers this work as being in 2 parts:

1. Technology Transfer (TT) – This is the adoption-of-new-practices part of the process. A new practice is developed, trialled and eventually disseminated to the rest of the users, mostly through peer-to peer-learning. This final process also forms the feedback process to steer the research for the future.
2. Knowledge Exchange (KE) –This is the 'exchange' of ideas, techniques and processes that exist in other industries into agriculture. This could be in any area; it appears to have worked well in the management structure of Embrapa itself, but it can also draw from all areas of research and all industries. This whole process could reduce the risk of duplication of research and 're-inventing the wheel'.

Strategic alliances

The whole process of extension relies upon the co-operation of private organisations and the public bodies. These alliances can be seen in action in the field. 'Agents' (mostly from seed producers) are very active within their marketing area working as extension officers as well as salesmen. Generally they have a high technical knowledge and are prepared to help the grower, even if it involves the marketing of another company's products. The general attitude is to benefit the farmer and, from this, secure the lucrative seed sale. This mutual-benefit attitude from these 'agents' appears to have built the respect of the growers who seem to use these agents as crop advisors. It must also be noted that, without the growers, the multinationals would lose a significant income stream from seed and chemical sales: the mutual benefit is significant.

This mutual-benefit attitude from these 'agents' appears to have built the respect of the growers who seem to use these agents as crop advisors.

Open days, trials sites etc

Due to the large scale of operators particularly in the northern States, plus a lack of infrastructure, this is not easy. As in most places in the world, field stations run open days, often part-funded by commercial organisations. Most of their work now evolves around soil structure, the build-up of resistance (through indiscriminate spraying), the management of water, and the importance of rotation. Demonstration sites have been operated for a large number of years looking at specific issues, such as soil and nutrient deficiencies. This is not unlike much of the long term work carried out by Rothamsted in the UK.

Whilst in Brazil I had the opportunity to visit a variety trial site (merchant run) and also one of the many Embrapa sites. The open day was not unlike a variety trial site in the UK, but as expected everything is bigger. Generally the plots are approximately 6 metres wide and 12 meters long, resulting in quite large trial sites. Viewing was also on a Saturday morning and appeared to be well attended, without the incentive of a free lunch which is often adopted in the UK. I also saw some of the seed companies' own trial work. Again plots were sizable and were 'warts and all': the representative was more than happy to show us the poorer and failed varieties as well as the successes. This gave the impression of confidence and openness from the merchant, an acceptance that not everything that they produced was a success in every location, and this led to a feeling of co-operation and partnership rather than a straight merchant-customer relationship.

My thoughts from the open day were that the 'farmers' in Brazil considered farming as a business rather than a way of life, and that these events were an essential part of their learning and their social life.

5.4. The work of co-operatives and 'agricultural societies'.

Agricultural co-operatives are still very widespread in Brazil, particularly in the southern regions where agriculture is more established. It is estimated that 37% of all farm output is marketed through co –operatives.

Cotrijal is probably the largest co-operative in Brazil, with 32 operating sites, (mostly in the southern States of the country), an annual turnover of between 500 and 750 million USD and a membership of over 5000. The organisation is now 55 years old and has just started to be seen as one of the powers of Brazilian agribusiness with a key role of linking the visionaries and entrepreneurs to general practice.

We were fortunate to visit their headquarters in Rio Grande do Sul. The operation is hugely professional, with a management team of 2 full time directors and a council of 18 elected members, and a members' forum of a further 84 members. The aim of the co-operative is to enable change. The farmers in the southern States generally have smaller holdings than those in the north. The Co-op aims to provide the most up to date knowledge, equipment and techniques to its members. In return the members are dedicated to the organisation, not only for purchasing but also for all sales of farm output. The business is not just dedicated to arable cropping, it also operates feed mills and markets livestock and other products produced by its members. It is also operating supermarkets to serve its members and the general public.

This southern area of Brazil is considered to be one of the birthplaces of the zero till system but does not have the large scale operations that are seen in the more recently developed northern areas. In Rio Grande do Sul the average 'farm' size is 40 Ha, and in its southern neighbour, Santa Catarina, this falls to 25 Ha. This is also the main home of the co-operatives.

By working together these co-ops can bring some of the best agronomic and veterinarian advice to their members, however small they are, giving access to the most up-to-date products and practices. There is also much co-operation between members with machinery, especially with specialist kit used in the formation of terraces, and zero-till drills.

The success of the co-operative society relies on individual members being dedicated to the operation and empowering the management team to make decisions.

The openness of the societies also allows accurate benchmarking and it is estimated that members' returns are 10% higher than those of non-members in the same region. The society makes technology affordable and reduces risk to the individuals.

The success of the co-operative society relies on individual members being dedicated to the operation and empowering the management team to make decisions. The structure of the organisation to ensure that everyone is suitably represented is critical to the overall success. Having met some of the members and the management team it is apparent that these smaller businesses are only able to survive by working in conjunction with the co-operatives, as this gives them access to pooled market values and input costs. The co-operatives' ability to 'add value' through their own centralised grain handling, storage and processing is shared with all the members.

…. it is apparent that these smaller businesses are only able to survive by working in conjunction with the co-operatives, as this gives them access to pooled market values and input costs.

Cotrijal started an annual 'agricultural fair' in 2000. Known as the Expodireto Fair this has become one of the key points where all areas of the industry meet to discuss and demonstrate technology and new opportunities.

Figure 3: Expodireto Cotrijal 2012 - aerial view

In 2009 Expodireto became an international fair.

6. Argentina

In general, agriculture in Argentina is more developed than in Brazil, with a much longer history. Accurate figures as to agricultural output are difficult to assess, but the University of Nebraska estimates that agriculture in Argentina in the early 2000s was responsible for nearly 50% of the country's exports, whilst it contributed 10% to GDP and employed approximately 15% of the workforce. It was also considered that output was falling, although the balance between crops and livestock was changing.

Government intervention is high, with more legislation on environmental protection and controls on production than neighbouring countries have. Taxation on agricultural commodities is also high, mostly in the form of export taxes on cereals

There is a State-operated agricultural research program, the '*Instituto Nacional de Technologia Agropecuaria'* or INTA. INTA's primary role is the 'generation, adaptation and diffusion of technologies' for agriculture, forestry and the agricultural industries. Its past success is masked by the political situation and sales restriction, and development in the industry is resistant to investment in cereal farming.

It became apparent during my travels in Argentina that the general reaction of the cereal farmers was to cut costs and continue production with minimal investment. Due to the export restrictions on wheat there was a large quantity in storage in 'ag-bags' on field headlands. Our hosts felt the governmental policy was to ensure that there was always a year's supply of wheat available in the country, thus ensuring that the prices remained low. This was creating serious cash flow situations for growers, and it was obvious from the age of the machinery in use that there was not a significant amount of capital re-investment in cereal businesses.

Figure 4: Ag-bag wheat storage in Argentina. This is a common sight on most farms

Livestock production is still a significant part of the system, although the inherently fertile soils are still being ploughed up and livestock numbers are falling. Crops were visibly poorer than the crops seen in Brazil a week before, but with the limited sales potential and reduced investment this was not surprising. In other discussions I have had with UK businesses that are heavily invested in Argentina is has become obvious that all forms of development are 'on hold' until after the general election in the country in late 2015, as it is considered there is likely to be a change in policy after that.

Despite the issues in arable farming there is some development in dairying. I visited a significant dairy development which was funded by a consortium of foreign investors. In this case the lead was from a North American, who used his model of milk production in Illinois and copied it directly into Argentina. Following the success of the first unit the consortium had invested in a second, and were

considering a third. They were also looking at other options to improve financial output, including the use of bio digestion to produce energy to make up for the lack of a central distribution network.

Figure 5: USA practices employed in South American dairying – recycling of sand bedding

Figure 6: Cow care is still critical on large scale units. In this instance each unit contained 4000 cows, with 2 units constructed and a 3rd planned

7. Australia

7.1. Australia – overview

As with most of the rest of the developed world, agriculture is Australia is coming under pressure particularly due to concerns over water. The weather extremes appear to be getting wider and sustainability is again a key word.

Similarly the average age of the farmer is now in the 50s. There also appears to be a common preconception that agriculture is not a 'career' - not unlike the situation in the UK and USA. Ever increasing pressures on farm margins has led to an exodus from the industry, and there are now serious concerns over skills shortages and the ability of the industry to change and adapt.

In the last 5 years Australian agriculture has consistently contributed approximately 2.5% to the GDP, despite the perception that outputs have been falling in real terms. The main contribution to GDP is from the service sector at almost 65%, with mining at approximately 6%.

As prices have come under pressure, Australian farmers have relied on increasing productivity to counter the long-term deterioration in profitability: input prices in broadacre crops have risen faster than output values. In the mid 1980s it was believed that output was falling, but since the mid 1990s this has started to regress, and agricultural output is remaining constant despite the financial challenges.

As a large land mass there are a number of differing agricultural systems in Australia, and also different legislation between States. This immediately creates different challenges between individual States, in particular the access to genetically modified or 'Biotec' crops. There are also severe climatic challenges, with the pattern of rainfall changing and creating new challenges especially as there is no 'blanket' State support for agriculture.

A major review of the Agriculture industry was undertaken by the government in 2010, and the result implied that there were significant export opportunities for Australian agriculture in the growing Asian market. In order to try and start to access this 'new market', spending on agricultural development rose, and there was a more formal agreement as to how this money should be spent. In developing agriculture the impact on the environment was also considered to be critical.

The governmental body controlling the program is known as DAFF, (Department for Agriculture, Forestry and Foods) which prior to 2010 held a budget of approximately $250m which was available for R and D via the Rural Development Corporations. The major review in 2010 identified that the spending on agricultural research and development was declining as investment was being made into environmental issues. It also identified that there was a small decline in broadacre systems. Having highlighted the national importance of agriculture there were recommendations that more money was made available for R and D and this should be spent in the following areas:

- 40 per cent: on long‐term outcome programs
- 30 per cent: on adjusting mid term programs to deliver 'quick wins'
- 20 per cent: on education and development of people in the industry
- 10 per cent: on international projects to build co operation.

At the same time it outlined some of the governance and monitoring that may be required to measure achievements. Part of this involved the Rural Research Development Council setting up some stakeholder surveys to try and guide the direction of the work.

The effect in the industry is varied. I did not have the opportunity to meet many 'farmers' on the mainland, but those that I met had similar concerns:

1. Shrinking margins in broadacre crops
2. Shortage of new entrants and a lack of desire for the next generation to continue farming
3. Changes in weather extremes.

7.2. Fresh produce in Australia

In discussions with marketing organisations and major retailers it became apparent that food retailers were encountering similar challenges to what is being seen in the UK: the rapid development of the 'discounters', namely Aldi and Lidl. It was estimated that the discounters had increased their market share by approximately 16%, a similar figure to that in the UK. The existing 2 major retailers were trying to adapt to this challenge, and it was unclear how this was likely to affect the growers.

The fresh produce markets were in a similar situation: major retailers were increasing their direct trading with the growers (via contracts etc) and volumes in the fresh produce markets were falling.

The market research that was available looked similar to that in the UK 10 years ago: an increasing reliance on major retailers, fewer visits and high expectations on quality. The UK now appears to be reversing this, with the large hypermarkets appearing to be falling out of fashion and a return to more frequent buying of smaller volumes by the consumer, and a concern over food waste.

7.3. Tasmania

As an 'outpost' from the mainland I was interested to see if the same concerns existed in Tasmania where the climate was a little less extreme. The main businesses I visited were related to fresh produce production, and most of their output was destined for the mainland.

Business is strong, although it was felt that legislative controls on environmental protection were difficult to achieve, and that little advice was available to help. Despite this innovation was high, although most of the work was their own rather than being available from third parties.

One such example of this was the development of the 'cold chain' for the harvesting and transport of broccoli. The crop, having been harvested, was transported to the nearest available site where it is soaked with borehole water for a period of approximately 20 minutes. This quickly removed the 'field heat' and from here the crop entered the cold chain. When quizzed about its effectiveness the reply was 'the difference between Sydney and Melbourne' – it is adding 2 days to the shelf life of the product!

This system of rapid cooling is as yet unadopted in the UK because of preconceptions that the crop must be kept dry at all cost.

Figure 7: Borehole water used to remove field heat (left) prior to hydrocooling (right)

It was not all new ideas; the onion harvesting system was made up of kit bought in the UK and exported in the last 5 years, and their production systems were also based on information from the UK, with a few 'tweaks' to allow for the different climate.

Figure 8: Red onion harvesting in Tasmania; most of the kit was imported from the UK

It is interesting to see that the key peer-to-peer learning can work across the globe, and the opportunity to see how other farmers in other parts of the world operate gives benefits.

8. New Zealand

This was my second visit to New Zealand: my previous one was in 2000 when my agenda was mainly to see onion growers exporting to the UK. I planned to revisit these growers and see what had changed.

8.1. Overview.

According to New Zealand's Office of Statistics, in terms of its economy GDP has continually increased to nearly 190 bn USD p.a., with the most rapid and consistent growth between 2006 and 2014. The contribution from agriculture however appears to be surprisingly low at 5.6%; the majority (unsurprisingly) comes from the service industry (67%). Agricultural products still remain the biggest export from the country.

The history of New Zealand agriculture has been challenged in the past; one of the biggest influences was probably the loss of the preferential exports to the UK when it joined the EEC. This forced the country to look for other markets and develop other trading partners. More recently this has been into Asia, with the formation of a large number of free trade agreements. It also has trade agreements with its nearest neighbour, Australia.

Despite these agreements the only sector of New Zealand agriculture that appears to be expanding is milk production. This has been fuelled by the share dairying agreements and the trade and processing from the large cooperatives. The industry however stands on its own feet, totally free from grants, support payments or quotas.

8.2. State Institutions.

In 1992 a series of Crown Research Institutions (CRI) was set up to conduct key research in the interests of the State whilst remaining commercially viable as businesses. In the case of agriculture the CRI is known as Agresearch. Funding appears to be match funded, with approximately 50% coming from industry whilst the government 'matches' this. Government contribution is currently approximately 75million NZ$.

It must be remembered at this point that agricultural products are the biggest export for the country, and remaining competitive and having a provenance of quality is of national importance.

8.3. Personal findings.

My experiences from 2000 were still with me. At that time farmers were considered to be some of the most important people around, and everyone wanted to buy you a drink in the pub. Young people were keen to get into agriculture, and it was considered to be a real career with high potential. By 2013 there appeared to be a change, in particular with dairy farmers, where the general public were becoming 'anti' farming, considering it to be polluting the environment with

waste and monopolising the water supplies. Some of this could be related to jealousy. Generally the dairy farmers I visited had been very successful, but their children were not interested in similar careers, and were looking for the opportunity to travel and leave the farms. Where does this leave the future of dairying? The succession laws appear to be complex, but generally it is difficult to pass a farm from one generation to the next. This is great news for new entrants, as farms are likely to become available, but there needs to be a desire to farm, and these new entrants potentially need considerable capital to start their business.

Many of the farmers are now in their 50s and looking for retirement, and in some cases are wondering who is going to buy their farms and livestock or continue the business. Despite these concerns the entrepreneurial spirit lives on. I met with 'John', a dairy farmer in his mid 50s. He and his wife had a 400 cow dairy herd, and had started as share dairy farmers, having spent a year working around the world to build cash to start the business. Although now looking to retire, John was still interested in new developments, so had built a low cost bio digester from his slurry pit. This consisted of covering the pit with a polythene liner, burying the edges and installing a 'gas collection' pipe system made out of surplus land drains.

Figure 9: A sheet covers the slurry pit to catch the methane produced.

He was very proud of this development, and was keen to show others how this was working, and that the gas he collected was suitable to burn. This spirit of sharing to everyone is commonplace in New Zealand, whereas in the UK there is more caution as individuals look for unique selling points (USPs)

8.4. Fresh produce in New Zealand.

With a limited home population significant quantities of fresh produce are exported. In order to maintain these markets quality is essential and significant investment is made in maintaining quality. The businesses that I visited are seeing the same problems as those in the UK in terms of labour supply and skills. In 2000 a major onion producer hand harvested almost 60% of his onion crop; this has reduced to 30% in 2013 due to a shortage of labour.

Figure 10: Hand harvesting onions in NZ – most of these were destined for the UK

Again, the problem solving at farm level was apparent, as steep slopes had created problems with stability when spraying, so specialist machines had been built to lower the centre of gravity and ensure stability.

Figure 11 (Left)

Purpose built sprayer to work on slopes with a low centre of gravity – a prime example of how innovation solves a problem.

Many of the other marketing ploys used in the UK are now also prevalent in New Zealand, with the use of brands and specialist varieties, such as the potatoes below:

Figure 12: Own branded product to try and boost sales

8.5. Legislation

Concerns from the general public appeared to have driven legislation on environmental control, partly as a response to the claims that the success of agriculture was threatening tourism and water supplies. This has led to legislation and pollution control measures as well as the construction of several large irrigation projects, based on water capture and storage for use in drier periods. The scale of many of these water projects was immense, almost as large as some of those used in California. Another key point with these projects is that they were generally collaborative and state supported, recognising the requirement to secure long term water supplies to keep the businesses operating.

Diffuse pollution was also considered a significant risk, in particular on steep slopes with 'young soils'. Another organisation I visited had developed their own system of building catchments and returning topsoil to the fields. This appeared to be an expensive option, reacting to the problem rather than developing systems to eliminate the problem.

See photo on next page

Figure 13: Sediment catchment pit – soil remains in the 'ditch' whilst water flows out via the barrels

Figure 14: repairing water damage. In some situations this is an annual process

Another example of legislation relates to the inheritance situation. As previously mentioned it is difficult to pass farms from one generation to the next without heavy taxation. One of the results of

this appears to be a lack of emotion over farms. Although individuals are passionate about their own farms they are also generally open to the idea of selling the 'family' farm and moving to another holding. In a large company situation this was very apparent. The business involved had a long history of 'trading' land, often buying traditional grassland, then arable cropping for 5 years before selling it again as improved farmland or as recently restored pasture.

8.6. Education

I had the opportunity to briefly discuss the higher education in agriculture. I was surprised to find that typical 'completion' rates on a degree course in agriculture were between 35 and 40% of the original starters. Although I do not have any actual figures for the UK I would be surprised if the rate was less than 90%.

In discussing further it became apparent that students do 'fail', a concept that may have been lost in the UK; and that this continues to drive standards. Due to this high standard many students do leave their courses before completion, often entering the industry without a formal qualification.

8.7. Summary

Farming without subsidies may have appeared hard but, with an open mind, businesses are successful. Government intervention supports the industry by enabling it to develop without giving direct subsidies. This and a spirit of co-operation is probably what allowed the dairy industry to develop so successfully.

In order to remain successful there may be a requirement to re-educate the general public and re-invigorate the passion with their agriculture.

9. The UK - overview

The UK has a limited landmass of approximately 240,000 square km and a population of just short of 65 million, making it the 22nd most populous country in the world. This high population puts extreme pressure on the resources of land and water, especially as the UK is a relatively affluent nation where the general public has a great interest in the environment.

It is now likely that less than 1% of the British work force is employed directly in agriculture (*ONS 2013*) and it returns approximately 0.5% of the country's £2.8 trillion GDP.

It is also estimated that the UK is only 62% self-sufficient in food. The UK is a net IMPORTER of wheat, despite exporting approximately 3 million tonnes of feed wheat; giving a negative trade balance of nearly £700 million in 2010. This is not unique to cereals; in almost every area of UK agriculture there is a negative trade balance (*2010 figures*).

Despite this, income in UK agriculture is falling in real terms. In 2012 total income fell to £4,704 million, a 14% fall year on year. Agricultural outputs appear to be remaining constant whilst costs are rising.

The UK agricultural industry is a well developed and highly traditional industry. In the past 100 years it has been forced to adapt and develop to meet the requirements of a rapidly rising population against a background of two world wars. In order to achieve this, government intervention has been necessary, both with legislation to help increase production during the wars, and financial inputs in the form of price protection, support payments and development grants. At the same time there has been considerable investment into research, development and knowledge transfer.

Post the Second World War a National Agricultural Advisory Service (NAAS) was established as an advisory and research wing of the then Ministry of Agriculture, Fisheries and Food (MAFF). This was designed to help farmers develop their farm outputs during the hardships of food rationing, which continued into the early 1950s. The NAAS was rebranded as the Agricultural Development Advisory Service (ADAS) in 1971. In 1992, ADAS became an Executive Agency of MAFF until the business was finally privatised in 1997. Since privatisation ADAS has developed into 3 major brands and are still involved in some agricultural research and development work on a contract basis.

In joining the EU the internal protectionism and price support moved to the European-based programme, controlled under the Common Agricultural Policy (CAP) with a system of support payments and minimum prices across all the member States to help guarantee food supplies and quality throughout Europe. This has been reformed many times in the last 60 years, and has moved from a system of intervention buying, quotas and price support to the current system of area-based support payments. The aim of these payments is to aid the development of farm businesses, to maintain food security and to allow legislation to protect the environment to become manageable by producers. Currently the EU spends c. £47 billion on agricultural support; of this c. £3.5 billion is spent on the UK. I had the opportunity to discuss some of the perceptions with an EU Minister at the ABRES conference in Canberra in 2013. In his opinion the system of area aid was delivering significant change and development, and that generally across Europe the area support was leading

to investment in technological advances in agricultural. I am still not sure that I agree with him in regard to the UK.

9.1. Research and development in the UK

There is little purely government-funded agricultural research in the UK. There are some long term projects that do have long term committed funding, generally in the maintenance of gene banks and genome work. Most other funding is through competitive tender or grant aid, and most of this is match funded. Applications for funding can come from a variety of organisations, institutions (colleges, universities etc), companies and private individuals as well as the levy boards, producer organisations and co-operatives who represent their various grower groups. The overall control of the government spending is the responsibility of BBSRC (Biotechnology and Biological Science Research Council), one of the 7 research councils in the UK. Total budget is approximately £500 million, but this is to fund the whole of UK research into biosciences including bioenergy and bioscience for health. Their mission is to 'promote and support, by any means, high-quality basic, strategic and applied research and related postgraduate training relating to the understanding and exploitation of biological systems' (*BBSRC 2015*).

This results in a large number of bodies producing a large amount of research from a large number of researchers that all needs to be communicated to the industry.

In the case of most private research there are often intellectual property (IP) agreements in order to limit the dissemination of the finding. This may be essential to enable the organisation to recover its development costs and to gain a competitive advantage, but what is the overall cost of this to the industry and the consumer?

These agreements can also lead to a duplication of research by different organisations as communication between them becomes restricted.

There is also a limited amount of trials work and KT work carried out by agrochemical and seed manufacturers with no support funding at all. Although most of this is for their own financial gain some principles and ideas appear. Here, the transfer of this knowledge is a key role of the organisation, as this is their only way of recovering their costs.

9.2. Knowledge transfer in the UK

With such a large number of top scientific agencies in the UK, and no one party responsible for the distribution of this knowledge, there are now a lot of interested parties involved. In order to try and gauge farmer feeling towards some of these operators a workshop was run (with thanks to Agritec East) to try and assess some farmer feelings.

This very basic workshop was carried out in Suffolk in late 2013. Two groups of farmers, farm owners, and farm business managers were asked where they got their advice from, how they kept up to date and who they trusted to supply advice.

The first group considered is the 'Farmer' group. Most of these were farming between 500 and 1000

Ha. The results from the Farmers' group are shown on the map below.

Some of the key points to come out were:

- **Trials results**: - demonstrations etc needed to be independent and local.
- **Trust:** - This came out very strongly. There was a level of mistrust where the outcomes of the advice led to a 'sale' directly to the advisor.
- **Social media:** - used by all age groups and was considered an invaluable tool. This included comments from peers on crops, pests seen as well as apps to help identify and share problems.
- **Peer to peer**. One of the strongest and most accepted form of knowledge transfer. This occurred in a variety of ways, from formal visits, farm walks and demonstration sites to the informal: the shooting field and informal newsletters.

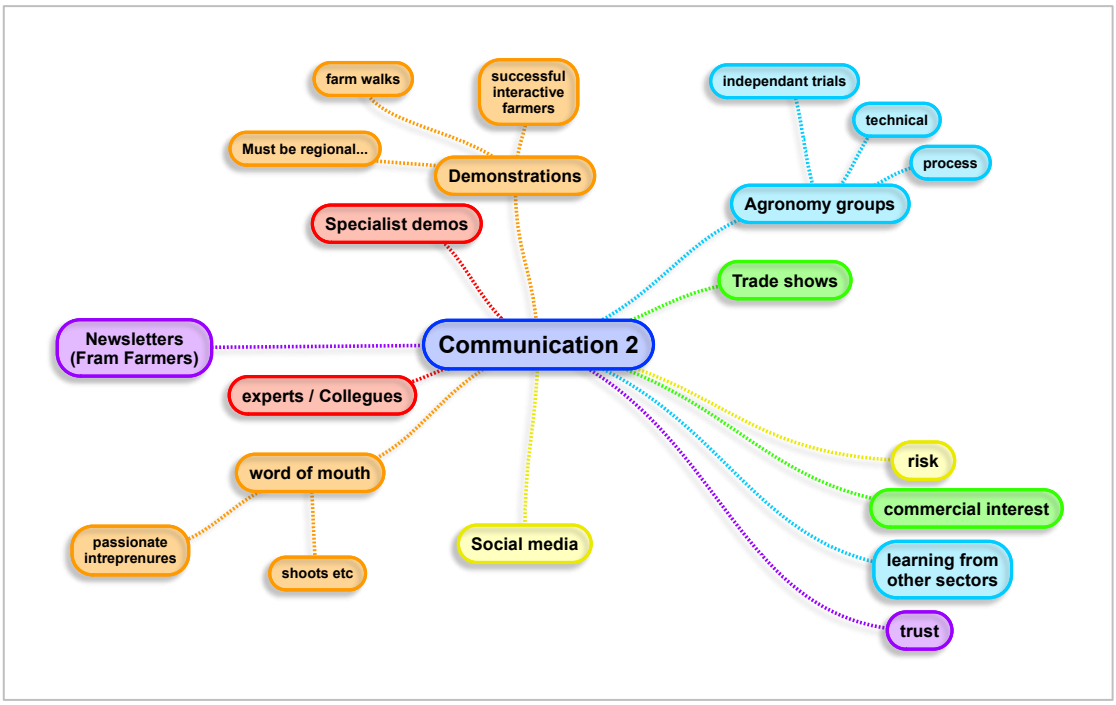

Figure 15: The 'Farmers group' – where do you get your information from?

Research establishments, colleges and conferences were often considered by this group to be 'too far away' or 'too far from practical application' to be beneficial. Another striking omission from the list was the Development or Levy Boards, although when prompted the group did agree that there was good information there, although the group members did not use it.

The group also identified that many lessons that could be learnt from other areas of industry.

The subject of time required to keep up to date, was also discussed. The general consensus was that group members were not able to commit enough time to stay properly up to date and keep their businesses running.

The second group consisted of larger operators, business 'leaders', managers and individuals from the wider supply base. The lists here were much expanded as shown in the map below.

The lists now became quite extensive, with ideas being established from some unexpected sources. In general it was felt that customer and regulation-driven change were not easy to accept, but in general had to be adopted. The levy boards were now considered to be a key part, and commercial organisations were an accepted source of information. In this group trust became a lower priority, as did locality. The local discussion groups, agricultural shows and the social events were also important.

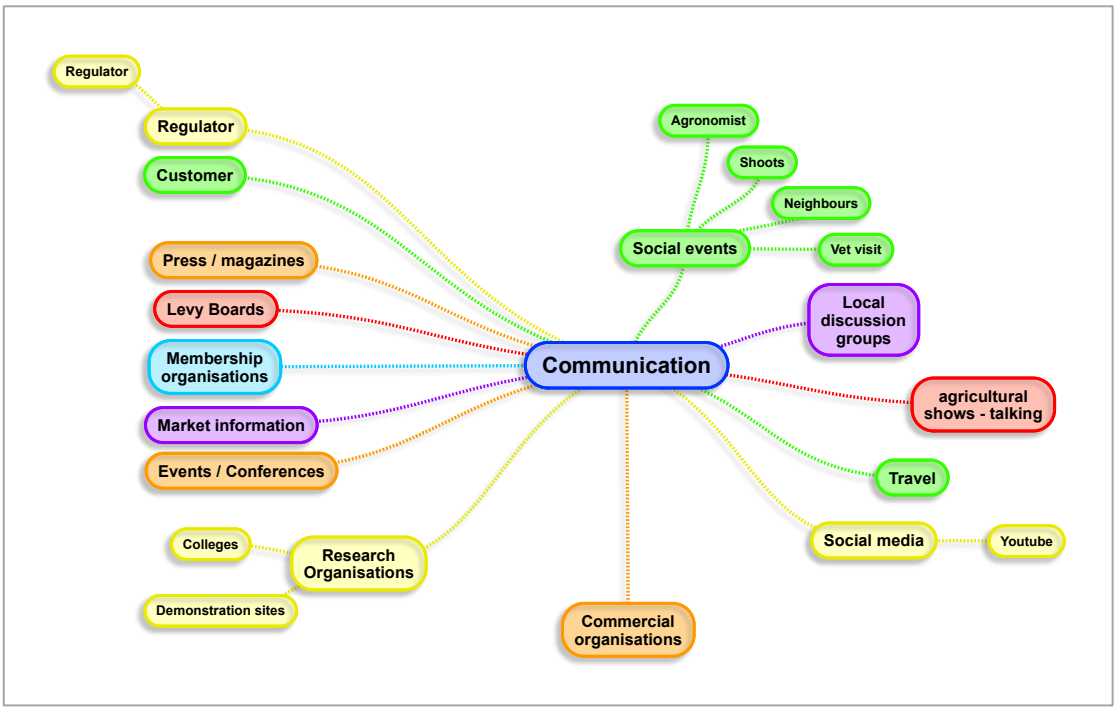

Figure 16: The 'Business managers group' – where do you get your information from?

The issue of time required was also discussed. In general it was considered that half a day a week was probably necessary in order to keep 'up to date'. Most managers were able to do this, many also taking a period away from their businesses to look at other operations in other parts of the country, or the world, through other farming groups.

During this discussion levy boards were highlighted as the organisation that may be in a key position to give impartial advice, although many growers and managers were not using the information available.

9.3. The Agricultural and Horticultural Development Board. (AHDB)

At the beginning of this study (January 2014) the main levy board in this country was operating as a number of separate entities under the one parent group. The industry was concerned about the

'service' offered and there were concerns over what was happening to levy payers' money. This is demonstrated by the results from the 'Farmers', who did not rate the levy board as a source of knowledge, but did, when prompted, accept that a lot of the information from other sources actually originated with the levy board. Aware that there were potential concerns the levy boards started to survey members to try and identify its strengths and weaknesses. One such study was carried out by the Horticultural Development Council (HDC) (now AHDB Horticulture).

HDC survey results

In September 2014 the Horticultural Development Board (HDC) commissioned a customer survey report to its members.

The results here were not dissimilar to the findings from the Suffolk workshop, although the responding group did change.

HDC report key findings (In terms of KT and development)

1. Members were aware of the technical publications, conferences and e-communications and trusted the technical information supplied.
2. The majority of responders did not consider the HDC as the first point of contact for this information, although they were generally aware of the services available.
3. The most useful form of communication was still considered to be a magazine, with significantly less interest in social media.
4. The use of the website was disappointing, but this may have been an 'ease of use' or training issue.
5. There appeared to be a low understanding of what research work was being carried out and where its commercial applications might be. Despite this, the respondents felt unsure that the HDC understood the issues of their business.
6. It was felt that the HDC was not helping in the development of markets overseas, nor was it promoting the industry.

(*After AHDB Horticulture 2014, Unpublished*)

This latter part of this report suggests that there is more of an understanding and communication issue as opposed to failure in another direction. Contrary to my Suffolk findings the HDC sample found that it was the farm owners who were most likely to respond to the survey.

The analysis of the 'responders' shows clearly that business owners were the most involved with the survey. This could imply that the 'owners' were smaller businesses who had a more 'hands on' role. It could also show that they just had more time available. There was also a level of response from actual growers. This report did not differentiate businesses by their size, so a second part of the survey looked at response rate by levy return. The levy return is calculated on the value of the sales from the business, so it indicated business size.

See chart on next page

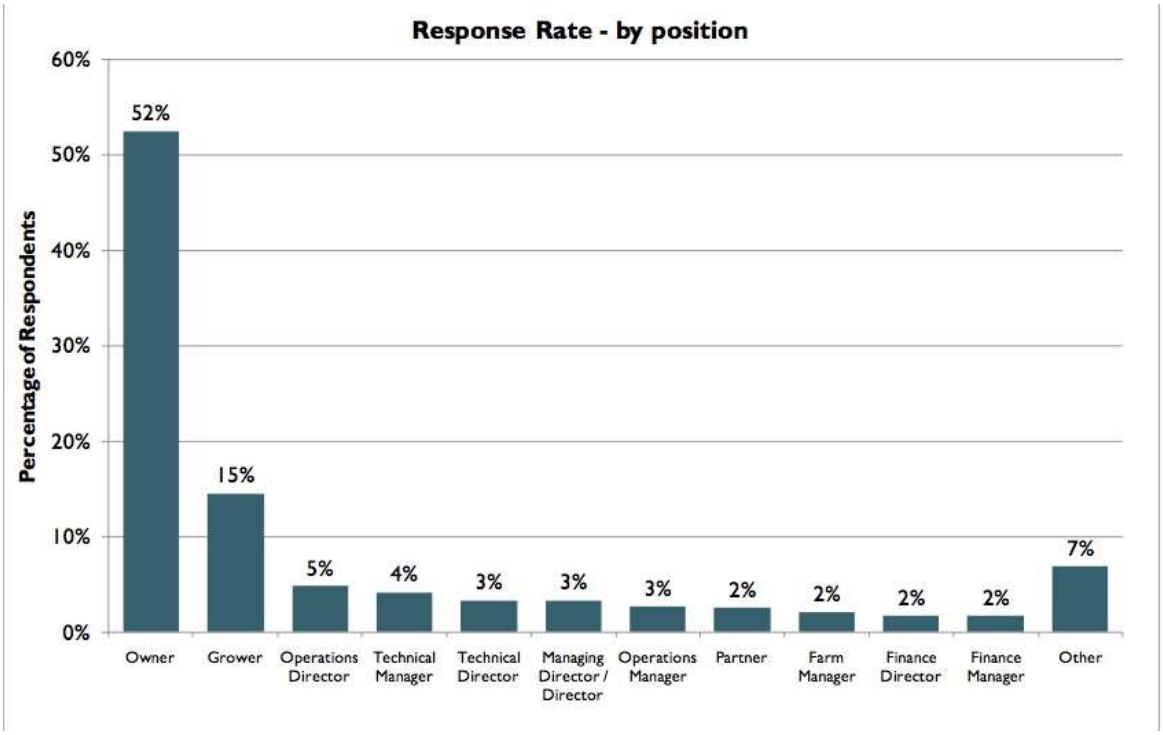

Figure 17: Responders to the survey by position in business

The second report (see chart below) appears to back up the first report in assuming that the majority of respondents were from smaller businesses, possibly owner occupied and managed. It could also be assumed that these businesses were less involved in their own R and D and were looking for a source of 'free' independent advice.

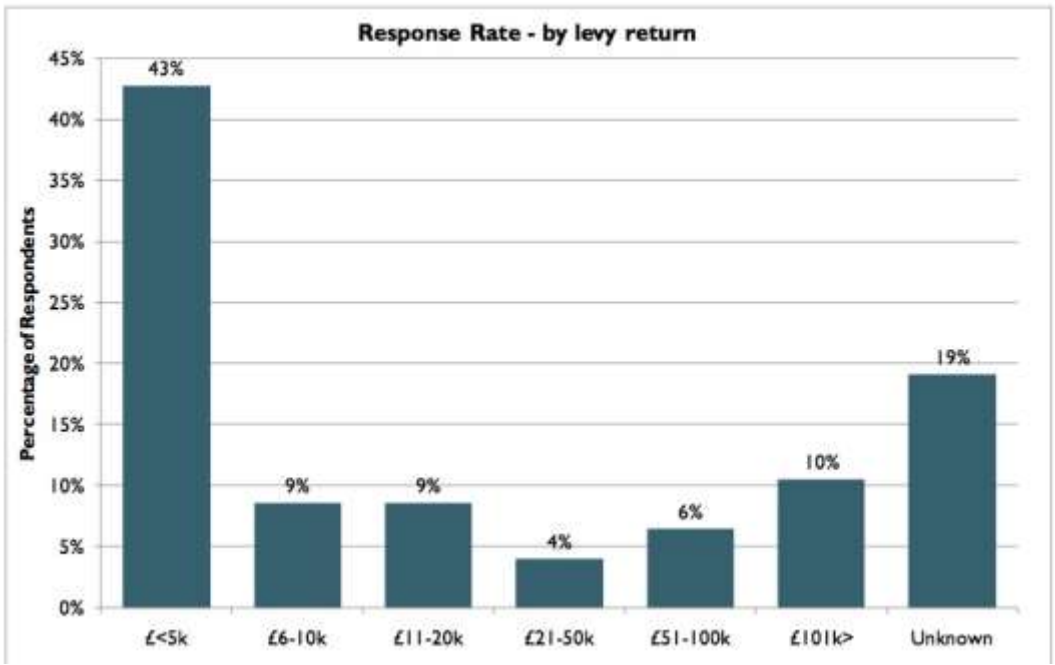

Figure 18: Responders by 'size of business' (assessed by levy paid)

It must be emphasised that the survey had looked at the horticultural sector, although in discussions it would appear that the issues may not be uncommon across all the levy boards in the UK.

9.4. Re-inventing the wheel

During some discussions with researchers from many disciplines it has become apparent to me that there is a lot of repetition and duplication between research organisations and industry on the same topic and idea.

This is particularly apparent with remote sensing and digital imaging projects. The onset of faster and better computers has enabled many more people to handle, analyse and use much of the 'big data' that we can now collect. This has re-invigorated the desire to assimilate information from aerial photographs using various types of photography and a multitude of aerial vehicles. A lot of money has been invested in these 'new' techniques which were in common use by the Ministry of Defence in the 1980s. While they were a military application these processes were covered by the Official Secrets Act, but the information and blueprints are now generally available. This is currently leading to a significant amount of duplicated research, as the original military research organisations were unaware that their work may be significant to agriculture.

Similar situations appear to occur with GPS, were the military has led; with robotics, where the car industry has led; and with genome analysis where medicine has triumphed.

Is there a way of transferring knowledge effectively between disciplines and how do we encourage this?

9.5. Summary of the UK

Without a single uniform organisation responsible for distributing knowledge the process appears a little haphazard and complicated. There appears to be a mistrust of many organisations and this is resulting in farmers not investing in new technologies as they are unaware of the true facts, despite the industry contributing £67million to levy boards annually.

The research community appears to be suffering from a lack of feedback, and therefore many projects appear to terminate at the paper publishing stage rather than the adoption stage.

This problem is not unique to agriculture, and most industries and disciplines often complain of the same issues.

10. The transfer of knowledge: 'leading the horse to water'

The perceived solution to the feeding of a growing population is to use 'sound well tested science'. In order for this to be possible we have to be able to translate that science into practice.

Whilst in the USA I was introduced to the analogy of the 'Valley or Chasm of Death'. This put research on one side, and the end user, in this case the farmer, on the other. The challenge is to pass the information from the researcher to the end user without losing it in the valley.

Figure 19: Is this the way we are passing costly information?

Although this process may appear straightforward there may however be a few more steps required. The information generated by science needs to be translated into practical application, and this application then needs to be adopted.

In order for the translation to occur the researcher needs to have a good understanding of both the problem and the practical application of the solution. The ARS process of assessing projects ensures that a practical application can be formed from the end result. The two-way communication also monitors the situation in the field; *does the problem still exist or is there an evolution of the problem?*

The process therefore needs to be a two way process. Maybe the superhighway (*see photo on next page*) is more like what is required: a 2-directional robust quick link between research and end user.

Even if this part is achieved, the practice, the process or technique still needs to be adopted by the farmer or end user to become a success.

The process could now be considered as having three stages:

Translation
Transfer, and
Adoption

Figure 20: information superhighway?

10.1. Translation

Before any new process, technique or application can be considered for practical application we need to ensure that it is practical and likely to give a benefit, be that financial or to the longer term good. If a clear financial benefit can be seen the chance of adoption grows significantly. If there is a long term benefit without a financial gain then the adoption rate will be lower.

In private research the financial benefit is the key. Without it the process or product is unlikely to sell; and without sales the research cost is not recovered.

In the case of some public research there may not be a financial benefit. The work could be to verify some already available advice, or to protect some existing pesticides from restrictions. In this case the finding may well end up in assurance schemes or legislation; so it is just as important to ensure that the application is practical.

In the USA this translation sits with academia and industry. Research by ARS would aim to be transferred to the private sector for the translation and transfer phases. Most academic research will have some form of joint funding with industry, so again there is a translation agent.

In Brazil there is now a large amount of private research, particularly into genetics and GM crops. Embrapa may be employed by industry to look at some of their results and 'translate' and verify the data. This then helps the transfer process as the information has become public. Practical field trials

at Embrapa can also help translate the data. The co-operatives are also involved; generally they have an understanding of their members' costs, and therefore can quickly assess cost benefits.

In the UK farm businesses are generally diverse. They may have a range of businesses in different sectors, and due to this the allocation of overheads to the cost of production is difficult. In order to translate some research into financial return it is normally marginally costed against the direct cost of production as a way of trying to draw any comparisons.

There are a large number of private organisations that will quickly try and assess a benefit from a new application, and use it in their own organisations or try to pass it on to their own members.

In general this process is successful, although there is adversity to RISK, and many new ideas are often rejected as carrying too much risk, or not giving a high enough rate of return. This has helped the UK to slowly destroy our soils, as low financial return processes are not carried out for the longer term good.

One of the key tools in the translation stage is a good understanding of the true costs of production.

10.2. Responsibilty

Without the Transfer step there cannot be any adoption, and therefore this passage of information is vital for the development of any agricultural system in any nation. There are many techniques adopted by different nations with varying success and cost.

There are now two types of information available.

1. **Scientific.** Results from research into solving scientific problems, such as pest management or crop nutrition.
2. **Market information.** Market research may be just as important as scientific research. Not only can it be used to identify selling opportunities, it may also be used to identify opportunities for new crops, or new industrial processes to increase the demand for a crop.

10.2.i. National programmes

Probably the most highly regulated system (and possibly the most costly) is adopted by the USA. This is not unlike the traditional system that existed in the UK in the 1970s and 80s, with a higher degree of regulation and a significant cost to the nation. It does manage to pass information in both directions, and the extensive network of extension officers does give confidence to the growers. In some cases the growers are even chasing their agents to find out trial results and relaying current problems back. The link with academia and with the national research programmes should also enable these agents to have a sound understanding from a number of different sources, not just the immediate work carried out by ARS or the land grant colleges. This in itself builds confidence, as the officers can draw on outcomes and findings from across the whole country, and to some extent from the rest of the world.

As well as the extension officers the land grant colleges run research units which are used to demonstrate some of the ongoing research. Regular open days are held which are attended by both grower and an increasing number of the general public (the 'end consumers') who are becoming more interested in where food comes from. This appears to be similar to the UK's demonstration farms form the 80s and 90s, which were also part of the national programme under ADAS.

In terms of return from investment the Brazilian government estimates that every R$1 invested in Embrapa results in R$13.2 return. This high rate may be assisted by the changing technologies supported by multi-national seed producers and a developing agricultural economy.

At what level should public funds be used to support agricultural research? In the case of Brazil, agriculture makes up a large part of the GDP; in the USA it is significant at 5%; but in the UK it only forms 0.5%. *At what point does food security take over from economics?*

10.2.ii. Producer funded programmes

Funding for these could be totally voluntary or on a compulsory 'levy' based system. Additional funding could also be obtained from governmental support, or even from manufacturers who can help support producer organisations' research as a 'verification' service.

10.2.iii. Membership schemes

These can be seen as the producer organisations (POs). Membership is not compulsory, and therefore the organisation has to be able to give 'value for money' in order to maintain its members. In many cases, although the membership is voluntary, the PO may well hold the sales contracts, and hence membership is required for access to the market.

In South America this co-operation, along with the extension work by Embrapa, fulfils the role well. All the farmers I met were well aware of the current research and where new issues may be arising, even if they were not ready to change their practices.

In New Zealand the growth of co-operatives has been responsible for the significant growth of the dairy industry in the last 20 years. These organisations can become a key tool, but will only work well in a truly open society, where the USP is for the group, not the individual. If greed takes over and individuals start to 'break away' the industry as a whole could become weaker.

10.2.iv. Compulsory levy organisations

Typically, in the UK, these can be seen as the levy boards. They form the 'formal' extension service in the UK, and have legal empowerment to collect levies from producers and use these levies to fund research projects and provide translation and extension services.

At the time of writing this report the levy boards in the UK were going through some dramatic changes. Many growers had become disheartened with the service from the boards, and had a lack

of understanding as to where the levy money was spent. This has resulted in a complete restructure, rebrand and development of the business.

All the original seven boards have now been merged into one base business: the Agricultural and Horticultural Development Board (AHDB). The management has been centralised (similar to Embrapa) to try and achieve savings and this centralisation is also planned to provide unity from all divisions of the new operation. Funding for this is still levy based, and in 2014 the total income from levy payers (both growers and industrial) was £60 million, across all the sectors. The remit is still to spend 50% on R and D and the remainder on market intelligence and development.

It is also worth noting that the New Zealand dairy industry now appears to be in support of a levy board system to complement or part-replace the co-operative system.

10.3. Adoption

Farms are businesses. They own assets, produce goods, and trade.

What leads to the adoption of a new process? How do other industries change?

In general all businesses appear to change for 2 reasons:

1. **Financial**: the business has to evolve to survive. A key example may have been the UK car industry which did not adapt quickly.
2. **Legislative**: a process or practice becomes 'banned' for a number of reasons. Key examples in agriculture include the loss of acid for desiccation of potatoes, and the loss of organophosphate insecticides.

The speed at which businesses change varies. In the case of financial requirements businesses change or go out of business. In agriculture this process is comparatively slow: the industry is asset rich, and heavily subsidised, resulting in resilience to change, especially if it involves risk. The continually increasing value of land is helping to support businesses, but is also increasing uncertainty.

10.4. Financially-led adoption

10.4.i. The challenge from current taxation and land values

For the last 50 years the value of land in the UK has risen at a rate that far exceeds inflation. Investment in land has been seen as an attractive proposition by commercial investors, pension companies and even private individuals. In general, the taxation on the sale of land once purchased limits its marketability. This has led to some of the very large land owners and investors being unable to sell land. As it has a high asset value investors and business professionals are looking for a higher and higher return on the capital invested in the land itself. This leads to increased rental values, and often shorter rental agreements.

These one-to-three year agreements cause a problem for the tenant. *How does a tenant invest in the land knowing that in three seasons' time he is likely to have to re-tender for the land? If he farms well, building soil fertility and reserves, his reward could be higher rents and/or loss of the land.*

This is not conducive to adoption of new techniques that involve investment in the land. The bio fuel incentives also add to this by increasing rental values in the short term. This, along with the current support payments is not conducive to change in a risk adverse industry.

There is also a lot of 'tradition' based around farms and land in the UK, and this along with the inheritance tax situation may lead to farms being operated at breakeven point because the current occupier does not want to lose the 'family' business. At what point do these businesses change – and is it early enough to save failing business?

10.4.ii. Monopoly 'forced change'

Probably the best examples of 'forced' change in the last 15 years have been seen in the UK sugar industry. In this example the monopoly purchaser had almost total control over quotas for production and price returned to farmers. As sugar quota reform loomed the purchaser had to act to keep their processing factories operating and ensure that the industry remained competitive.

As a monopoly purchaser the processor had been able to fix strict quotas on supply. Growers either had to grow for the monopoly or not grow at all. In order to support its monopoly status the processor has been hugely pro-active in research and encouraging change. This has reduced the average growing cost (and increased yield) enabling the industry to reduce its area by almost 50% since 1982. These are the headline achievements since 1982:

- 60% increase in sugar yield per hectare
- 40% reduction in nitrogen application
- 70% reduction in phosphate application
- 60% reduction in total agrochemical used
- 48% reduction in the area required to reach national quota
- Reduction in average distance from the factory to 28 miles
- Sugar extraction process now uses 25% less energy
- £1.8 million fund annually for research and development in the industry through British Beet Research Organisation. (BBRO)
- *The aim is to future-proof both industries through co-operation.*

This is a great success story for British Sugar, although it has not been trouble free. The continuing decrease in the price paid to farmers has been difficult to swallow. In order to maintain some confidence between grower and processor the National Farmers Union (NFU) became involved to represent the growers and lobby the processor of a 'fair and transparent' price for sugarbeet produced. This led to the formation of the inter-professional agreement. This agreement set a pricing mechanism which links crop production costs and hence crop margin to other key crops. In doing this it allows for changes in currency and oil price, as well as makes adjustments for changes in practices in sampling and payments. *The aim is to future-proof both industries through co-operation.* During much of this change I was a sugarbeet grower with several different businesses, and many

times had the discussion as to how we could reduce costs and increase yield in order for the crop to remain profitable. I can also remember attending many of the 'crisis' meeting organised to discuss how growers could challenge the processor. The actual reduction in the number of sugarbeet growers throughout this change is not advertised, although many smaller growers have joined forces to set up grower groups to ensure that they could be properly represented and benefit from the economies of scale.

In order to encourage change and help both the processing factories and the grower a research and development programme was set up funded by both the processor and the growers (similar to funding for AHDB). Known as the 'British Beet Research Organisation' (or BBRO) it is responsible for working on the 5-year development plan which addresses both processing and growing challenges and is in constant communication with both. One of its many roles is also the validation of research data before it is disseminated to growers or the processor. This ensures that there is an independently trusted source of knowledge that the whole industry has access to. Some of this knowledge is disseminated through the grower support programme, the key provider of information for the grower.

BBRO partners many of the UK's leading research facilities to carry out the research required, and also monitors progress and performance. As well as monitoring the success of the research it also monitors the success of knowledge transfer, via the Grower Support Programme. Together the processor aims to increase the international competitiveness of its industry. British Sugar however is not exclusively operating in the UK, it is now operating a factory in China, although investment in the UK does continue. This sends a solid message to UK growers – 'stay competitive in a worldwide market - or get out'.

As a whole this is a great success story, although it was often not easy. In order to begin the change British Sugar started its own growing operation; this allowed them first-hand experience of growing the crop. The challenges they met could then be fed to BBRO to 'kick start' the research programme. It also made a statement to the industry that the processor was serious about reforming its industry and supply base.

The UK sugar industry is unique as it holds a monopoly to process all crop produced. In fresh produce we have less than 10 main purchasers. Although each of these does have significant buying power none is in a monopoly situation. They do however still have the ability to change growers' practices and procedures. As growers we still have the opportunity to form grower groups and then 'partner' some of the purchasers, and build a more competitive future for both grower and purchaser.

10.5. Legislative and consumer-led change

10.5.i. Legislative change

The 'outlawing' of certain practices and products has 'forced' change. Some of the best examples in the UK are based around environmental protection. The examples include restrictions on ploughing up traditional grassland, NVZ and anti-pollution laws, as well as restrictions on how intensive livestock units operate. In these cases the requirements are governed by UK or European law. This is

different to guidelines given for cross compliance or assurance schemes: in these cases a failure to comply could result in legal action. In general there is some warning of these changes, although it is becoming more apparent that the science behind some legislation may have been flawed. *As growers are we well enough represented when new legislation is introduced?*

10.5.ii. Crop assurance, codes of practice and cross compliance

In the late 1990s crop assurance started in the UK. The aim was to promote a high quality food product, ethically produced on well-run UK farms. The introduction of assurance schemes started to encourage change and development across all sectors, but in particular the fresh produce sector. The original schemes operated on a minimum production standard aimed at ensuring higher levels of food safety, environmental protection and good practice. The scheme is still optional, although most of the major retailers insist on achievement of the standard as a minimum requirement of supply. Initially the creation of the standards led to a general step change in production processes and an increase of professionalism. Some relatively small requirements, together with an inspection and audit process, led to these changes. Since its introduction in the late 1990s a large number of new standards have been created. Generally these all add to production standards, but the complexity of the schemes could now detract from the underlying aim of ensuring the best food quality.

The introduction of direct and production based subsidies in the early 1990s also led to a step change in production. A series of 'codes of good agricultural practice' was introduced, and although not obligatory, they were a requirement to claim the new subsidy. As the schemes have changed, so too have the requirements now referred to as 'cross compliance" which are applied across the whole of the EU. This has also formed some of the justification for the £3.5 billion spend on the Common Agricultural Policy in the UK. In real terms this payment is subsidising the production of home grown food. *Is this the correct way of supporting food security?*

10.6. Education and public perception

In most of the countries I have visited agriculture appears to have lost is appeal, although new interest in food and its production may just be starting to change this. In a management role in the UK I was shocked to discover that a group of visiting schoolchildren did not understand that carrots grew in the ground; what was worse was the fact that the teacher didn't either. If UK agriculture is going to recruit the 'best' people and future leaders how do we address this?

In the UK the situation may have started to improve as agriculture gets a higher profile on television. and the desire for 'higher quality' food increases, people become interested in its source. This has led to increased numbers of visitors at events such as Open Farm Sunday and other farm open days. There are however some lessons to be learnt. I recently stood by a pen of fattening pigs at an open day and overheard a child ask her parents if they all had to die to become pork. To my relief the parent declined to respond.

It is obvious from this example that as an industry we need to be able to promote ourselves with a well balanced and scientifically proven argument for what we do. Once we have a population that has become interested in the industry we need to be prepared to train individuals in the best

practices and with the newest techniques. The preconception in schools that '*you can't read or write so you'd better work on the land*' needs to be banished and agriculture become the dynamic and exciting career that it really is.

10.6.i. Is agricultural education in the UK failing the industry?

My thoughts are: probably. The current college generation appears to be in a bubble where failure is a banned subject. Without this how do employers select a workforce when the qualifications are now so complicated and misunderstood? With little understanding of the politics of education it appears that student numbers are more important than the ability of the individual and this in turn results in people studying agriculture with no real interest in the industry.

Part of the solution adopted currently is apprenticeships. In principle these should deliver good operators who are up to date with the practices on the unit where they train. Does this lead to innovation and development, or just help continue with the preconceptions that '*we have always done it this way*'?

Figure 21: Are we at risk of this being the epitaph of UK agriculture?

11. Key points

1. UK agriculture generates less than 0.5% of the GDP, employs less than 1% of the population and is subsidised by £3.5 billion annually to produce low cost food and give a level of food security.

2. Current consumer requirements for 'out of season' and exotic produce help reduce the country's self-sufficiency to 62%.

3. Agriculture in the more developed world is a very traditional industry with a significant history and a series of preconceptions. This is a trend that appears to be developing in the newer nations. It is most prevalent in broadacre farming systems where financial margins are smaller.

4. In the UK high land values, tax laws and short term tenancies may reduce the investment in our key resources of water and soil. This may be heavily supported by current subsidy strategy.

5. There appears to be little communication between research and practical application, known as the 'Valley of Death'. This, together with a large number of organisations carrying out different research with little co-ordination or leadership results in overlap and mistrust of results.

6. The lack of a single respected body to co-ordinate education, application and research is resulting in multiple organisations trying to fill the cap and possibly losing focus on their primary role. Maybe there needs to be a body that can co-ordinate all parties involved.

7. The demand for affordable food in the 1970s and 80s has led to a disjoint between consumers and producers and a possible mistrust between the general public, food producers and researchers. Recently this trend has started to decline in the more developed countries with a move to 'organic and locally produced' food and a more open farming community. Better education of the general public as to where and how food is produced may help to regress this.

12. Conclusions

1. There is a disjoint in the UK between research, producers and consumers

2. In order to increase the security of food and the future of UK agriculture there is a requirement to:

    a. Co-ordinate research and current extension bodies
    b. Validate trial results
    c. Translate findings
    d. Transfer producer challenges to research
    e. Educate the public and recruit new skills through academia
    f. Co-ordinate the development of new markets and market opportunities
    g. Liaise with regulatory and assurance bodies to ensure that production protocols are based on good science that is deliverable in practice
    h. Encourage and educate the new entrants and co-ordinate training and apprenticeships to deliver

3. If UK agriculture is to be ready for the third agricultural revolution we need to accept that change is necessary and work together to ensure that the right changes are made for the right reasons.

13. Recommendations

1. With the UK's high production costs it is unlikely that it will be a competitor on the world markets with commodity products. Therefore, in order to maintain a margin, the UK will have to be able to develop its systems to reduce cost and increase sustainability. Working as individuals against the rest of the world is likely to be a recipe for disaster.

2. The UK has a history of being a pioneer in agriculture and it still has some of the best research establishments in the world. It also trains some of the best people in the world, yet our own development appears to have stalled, particularly in the past thirty years.

3. In order to accelerate the rate of agricultural development and change we need a united, single, dedicated approach to tie together all the researchers, KT operators, academia, the markets, the general public and the producers. This currently appears to be missing.

4. This may be the new role for the re-developing AHDB. In order for this to happen and for the AHDB to succeed the whole industry needs to support them, supply them with the opportunities, discuss the threats and maybe, by working together as a nation, we will have a chance of competing on the world markets.

14. Executive summary

The world is an ever changing place. Many have commented on how we are to feed over 9 billion mouths by 2050 without destroying the planet we live on. The answer is likely to be through sound, well-tested science, but in order to employ this science we need to ensure that it is the correct science for the region.

Our farmers, growers and food chain need to understand it, how to apply it, its weaknesses and strengths, threats and opportunities. This is the role of Knowledge Transfer (KT). In return our scientists need to understand where the new problems lie, and need the farmer's help in finding the solutions.

It is accepted that there is a metaphorical chasm between research and application, and the role of KT is to bridge this chasm in both directions, feeding fresh challenges to researchers and fresh ideas to producers.

The UK probably has some of the 'best' research facilities in the world, with many top level researchers working inside them. It has an agricultural system that is full of tradition and heritage, yet employing less than 1% of the workforce and producing less than 0.5% of GDP. The country is only 65% self-sufficient in food production. The agricultural industry across the whole of Europe is heavily subsidised with various schemes to help businesses develop and to enhance the environment, yet most of the research is privately commissioned using private monies, raised from individuals or through levy boards. The knowledge of what is being researched, new developments and their applications, is sporadic. There is also a level of parallel research as most privately commissioned work is covered by intellectual property (IP) agreements before work is started. Even when producers are aware of the developments there appears to be a mistrust, slowing adoption.

How do we improve our research and KT? It currently appears that there is a reasonable flow of information from research to the producers; unfortunately the opposite is not happening. The '*bridge across the chasm is for one way traffic*'. Researchers in many establishments are not involved with the field application of their work, which results in their not always seeing the new challenge or the new problem. In many cases the issues resulting in slow adoption may be 'quick wins' if research was fully aware of the situation in the field.

In order to 'expand the bridge' and improve the flow the producers need to be able to work together, and there needs to be some co-ordination and 'leaders' in order to drive the process.

The roles of co-operatives, producer organisations, supplier groups, agricultural societies, academia and many other organisations need to be co-ordinated, targeting resources into specific areas of research, reducing duplication of work and looking at what has already been achieved in other industries. Working together could streamline research and KT, and enable adoption as consistent, reliable, trusted information becomes available.

Is this one of the roles of the re-structured AHDB?

15. After my study tour – what next?

UK agriculture is changing at such a rapid pace it may become difficult to keep up. Thoughts that there is a skills shortage are still paramount, but the size and requirements are changing. I think the requirement for people will continue to fall as automation increases and this will change the people that the industry requires. This training will take time, and therefore we need to be ensuring that time is available for the future operators. These may well come from non-traditional backgrounds – agriculture is likely to need data and imagery analysists, electronic engineers and computer technologists as much as it needs tractor operators and shepherds.

There is also a need for training for the current operators. There are many opportunities here, although most are still developing. Several organisations are tasked with forming 'centres of excellence' to provide some of this training. Personally I am involved with the Centre of Contemporary Agriculture operating in the eastern counties.

One of the keys is breaking the preconceptions in young people and encouraging new entrants. This may require a level of 'public relations' in order to try and educate the general public (our customers) in where their food comes from, and how UK-produced food is some of the best in the world. There are many levels to this, from the work of LEAF with 'Open Farm Sunday', via our annual county shows, to the BBC with their 'Harvest 2015' programme. I would like to be involved, by whatever means we can, in bringing agriculture into the consciousness of all children as a dynamic, high tech and very rewarding career. For this to succeed we need some leaders, both individuals and organisations, to work TOGETHER rather than different groups or organisations who prefer to work to their own agenda.

As an industry there is huge potential within the UK. We as leaders and Nuffield Farming Scholars, need to work together to promote our own industry. If we all work together we can create a long term profitable and sustainable industry.

Mark Bowyer

16. Acknowledgements and Thanks.

Firstly I would like to thank the Royal Norfolk Agricultural association for their generous sponsorship and support during the last two years and, prior to that, for their encouragement to apply in the first place. I am also most grateful to other Norfolk Nuffield Farming Scholars, in particular Mr Lyndsay Hargreaves and Mr David Hill, who also encouraged me to apply.

I must also thank Produceworld Group, in particular Mr Jason Burgess for allowing me the time away to complete my studies, and Miss Carolyn Coxe, Mrs Helen Banham and Mr Matt Sissons for managing to keep the farm operating during my periods of absence.

Thanks and appreciation to my fellow Scholar, Russell McKenzie, for his work in organising and being my travelling companion in South America.

To Melanie Peterson of the Office of International Research Programs in the ARS/ USDA, for setting up a fantastic itinerary of meetings and visits across the whole of the USDA, and whom I never got to meet personally and Belinda Clarke of Agritech East, who enabled me to discuss extension with farmers and business managers in the Suffolk workshop.

Miss Pip Betts, my long term partner and rock, who holds everything together when I disappear for long periods of time; looks after the menagerie of livestock I leave behind and without whom I would never have managed to complete this project.

Thanks also to everyone that I have met across the world, and also to those who made people available for me to meet. There are too many of you to mention personally, but my heartfelt thanks go out to you all.

Last but by no means least, the Nuffield Farming Scholarships Trust as, without them, none of this would have been possible.

Figure22: My sponsors – The Royal Norfolk Agricultural Society

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